NUREG-0879

Environmental Assessment for the Barnwell Low-Level Waste Disposal Facility

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**Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555**

SUMMARY AND CONCLUSIONS

This Environmental Assessment has been prepared by the U.S. Nuclear Regulatory Commission in response to a request on January 29, 1980, by the South Carolina Department of Health and Environmental Control (DHEC), Bureau of Radiological Health, for technical assistance in evaluating the environmental impacts of the Barnwell Low-Level Waste Disposal Facility operated by Chem-Nuclear Systems, Inc. (Chem-Nuclear).

The disposal facility is located approximately 8 km (5 miles) west of Barnwell, South Carolina, near the southeastern perimeter of the Savannah River Plant. The disposal facility consists of about 121 ha (300 acres), 95 ha (235 acres) of which have been deeded to the state of South Carolina as an exclusion. The Barnwell facility was receiving a waste volume of up to 67,968 m^3 (2.4×10^6 ft^3) annually but by October 1981 will be limited to a maximum annual waste volume of 33, 984 m^3 (1.2×10^6 ft^3).

This assessment was limited to an evaluation of the environmental impacts associated with the following actions:

1. closing the site and implementing site closure and stabilization plans,

2. continuing operations under current conditions, or

3. continuing operations under altered conditions. The staff has recommended that operations continue, with due consideration given to the staff's recommendations concerning site operations. The staff believes that the implementation of these recommendations will aid in improving the overall effectiveness of the Barnwell facility in both the short and long terms.

In this environmental assessment alternatives in the following areas were considered:

1. no action,

2. operational procedures,

3. financial guarantees for compliance, and

4. methods of minimizing the potential for radionuclide release and transport over the long term.

From the analyses of the environmental impacts associated with the actions and alternatives stated above, the staff suggests that the following recommendations concerning the Barnwell facility be given due consideration.

1. The final disposal volume and costs for decommissioning of site structures and equipment should be well documented and updated periodically (Sects. 2.4.1 and 2.5.3).

2. Direct gamma radiation surveys should be continued at specified time intervals, the procedures and methodologies should be well documented, and the results should be forwarded to the DHEC (Sect. 2.4.1 and 2.5.3).

3. The State of South Carolina should give serious consideration to and present the applicant with some conceptual plans of what it intends to do with the site after final decommissioning (Sects. 2.4.1 and 2.5.3).

4. Chem-Nuclear should construct hydrographs for each well, indicating all historical water level changes. Piezometric maps should also be compiled on a quarterly basis to account for seasonal variations in the water table level. (Sects. 2.4.1 and 2.5.3).

5. The term "Statistical increase" with respect to environmental samples taken during operation and stabilization should be formally defined by Chem-Nuclear and DHEC (Sects. 2.4.1 and 2.5.3).

6. Measures to be implemented by Chem-Nuclear in the event that any evidence of unusual or unexpected rates or levels of radionuclide migration in groundwater is detected should be documented (Sects. 2.4.1 and 2.5.3).

7. Condition 15 of the site closure and stabilization requirements should be evaluated periodically against the results of monitoring (Sects. 2.4.1 and 2.5.3).

8. The groundwater monitoring program should be expanded to include analysis of nonradiological parameters (Sect. 4.1.1.2).

The staff's analyses of the environmental impacts resulting from continuing operations of the Barnwell facility are the following:

1. Continued operation of the waste facility will have no appreciable effects on air quality. Emissions of fugitive dust and combustion emissions from equipment operation are expected to be minor.

2. The major land use impact relates to the long-term exclusive use of the site for the ground burial of low-level radioactive waste. After disposal capacity is reached, it will be several hundred years before the site could be released for unrestricted use.

3. The potential for contamination of local streams by both surface runoff and groundwater contamination is highly unlikely. Potential impacts on groundwater during the remaining expected life (25 years) of site burial operation are expected to be minimal. Over the long

term some degradation of the goundwater benath the site may occur, but the staff's modeling indicates that the effects would be well within the limits of 10 CFR Part 20 and the proposed 10 CFR Part 61.

4. There will be no impact on potential mineral resources. Impacts on soils will be minimal.

5. Impacts on aquatic and terrestrial biota are expected to be negligible.

6. The radiation dose to members of the general public will be insignificant. Personnel exposures received during normal waste disposal operations are considerably less than current NRC standards.

7. Continued operation of the waste facility will not produce any significant socioeconomic impact on the local area.

8. The staff opinion is that any potential accident postulated for this project will not result in significant damage to the environment.

In conclusion, the staff has found that the Barnwell facility is operated at the forefront of technology related to the shallow land burial of low-level waste. The staff recommends that the present operations continue, with due consideration given to the recommendations listed above. The staff believes that these recommendations, if implemented, will aid in improving the overall effectiveness of the facility in both the short and long terms.

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1. PURPOSE OF AND NEED FOR THE ACTION

1.1 INTRODUCTION

This Draft Environmental Assessment has been prepared by the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Material Safety and Safeguards (NMSS) in response to a request on January 29, 1980, by the South Carolina Department of Health and Environmental Control (DHEC), Bureau of Radiological Health for technical assistance in evaluating the environmental impacts of the Barnwell Low-Level Waste Disposal Facility (BLLWDF) operated by Chem-Nuclear Systems, Inc., (Chem-Nuclear). Although South Carolina is an Agreement State and therefore has the licensing authority for LLW disposal in South Carolina, the state's actions in this regard are not within the purview of the National Environmental Policy Act (NEPA) of 1969. Consequently, a formal environmental assessment or impact statement has never been prepared on the BLLWDF.

In addition, the Office of Nuclear Material Safety and Safeguards (NMSS) has prepared this assessment to be responsive to a January 1976 General Accounting Office (GAO) report to Congress and a July 1976 House Government Operations Committee recommendation. The GAO report pertains to evaluating the ability of existing commercial sites to retain radioactive wastes; the House recommendation is aimed at improving the performance of LLW sites.

Another important consideration was the expectation that prospects for additional LLW sites in other states will be submitted that will require NRC licensing action. Therefore, a full review of design, operations, closure, and stabilization requirements and alternatives at this operating LLW site will provide the NRC staff with improved assessment capability in examining new proposals and choosing alternatives, operating conditions, and monitoring requirements that will protect the health and safety of employees and the public in the near term and for the foreseeable future.

The applicant has submitted an Environmental Assessment (EA) of the facility. In preparing this document, NRC representatives (the staff) reviewed the EA and met with the applicant to discuss items of information in the EA, to gain additional information that might be needed for an adequate assessment and, generally, to ensure that NRC has a thorough understanding of the BLLWDF. In addition, the staff sought from other sources information that would aid in their evaluation, conducted field inspections of the Barnwell site and surrounding area and met with State and local officials charged with protecting state and local interests. On the basis of the foregoing activities and other such activities or inquiries as were deemed useful and appropriate, the staff has made an independent assessment of the Barnwell LLW site. The NRC has concluded that it is in the public interest to prepare this assessment in general conformance with the NRC regulation (10 CFR Part 51), which implements NEPA requirements.

1.2 SUMMARY OF THE ACTIONS CONSIDERED

The State of South Carolina authorized the burial of LLW at the Barnwell site in 1971. The Atomic Energy Commission (AEC) issued a license allowing the disposal of Special Nuclear Material (SNM) at the site from February 1973 through December 1974. Federally licensed burial of SNM was reinstituted in January 1976. The burial of SNM has always represented a minor addition to site disposal operations and as such did not require a formal NEPA assessment. Plutonium burial has never been authorized at the site.

Because the BLLWDF is already in operation, the alternative of not allowing the facility to be licensed and constructed was not viable. The staff was limited to an evaluation of the environmental impacts associated with the following actions:

- closing the site and implementing site closure and stabilization plans,
- continuing operations under current conditions, or
- continuing operations under altered conditions.

Specific issues under these actions are discussed in later sections.

1.3 FEDERAL AND STATE AUTHORITIES AND RESPONSIBILITIES

Chem-Nuclear, the site operator, is licensed by the state of South Carolina under Radioactive Material License No. 097, which contains specific requirements concerning the manner in which LLW is disposed. The DHEC continually observes site operations to ensure adherence to license conditions.

The disposal of the small quantities of SNM buried on the site is controlled under NRC License No. 46-13536-01. The service facilities on site are permitted or licensed under county and state ordinances and laws applying to any commercial enterprise.

The transportation of LLW to the site into and within South Carolina is regulated under South Carolina Department of Health and Environmental Control Regulation No. 61-83. This regulation implements the South Carolina Radioactive Waste Transportation and Disposal Act (Act No. 429) of 1980, which amended 13-7-10 et seq. of the 1976 Code of Laws, The South Carolina Atomic Energy and Radiation Control Act.

The packaging of radioactive material for transport and the transportation of radioactive material are controlled by the NRC regulations in 10 CFR Part 71, as well as the Department of Transportation regulations in Chapter 1 of 49 CFR, Research and Special Program Administration, Parts 171-179, subchapter – "Hazardous Materials Regulations," and Chapter III, Federal Highway Administration, Parts 386-399, subchapter B – "Federal Motor Carrier Safety Regulations."

1.4 NEED FOR THE ACTION

There is no specific action contemplated. This is an assessment of the environmental impacts of the Barnwell Low-Level Waste facility. The NRC is required to provide technical assistance to agreement states upon request. As was previously noted, the State of South Carolina made a formal request for assistance in reviewing the operation of the BLLWDF. This assessment will assist the State of South Carolina when consideration is given to regulatory actions concerning the facility.

1.5 RESULTS OF THE SCOPING PROCESS

In accordance with implementing rules in 10 CFR Part 51, the NRC utilized a scoping process to identify the significant issues discussed in this environmental assessment. During the review of the environmental assessment prepared by Chem-Nuclear of site operations and peripheral effects, the NRC staff identified major areas of concern that should be carefully assessed in the environmental assessment to be prepared by the NRC staff. The most important issue identified was the degree to which a potential existed for the long-term migration of buried radionuclides back into the biosphere, with subsequent radiation exposure to biota, including man. This was confirmed during a later meeting by the staff with members of the DHEC. They requested that the water transport of radionuclides be particularly emphasized.

In addition, the DHEC requested that alternative methods of unloading and depositing wastes be in place before final coverage. The objectives are to be

1. a reduction in occupational exposure,
2. the retention of packaging integrity, and
3. the elimination of void space during backfill operations, to minimize long-term subsidence after initial reclamation.

The DHEC also requested that the possible advantages of a uniform waste classification scheme with waste segregation during burial be considered. The staff considers this to be beyond the scope of this assessment.

2. ALTERNATIVES, INCLUDING THE CURRENT METHOD OF OPERATION

The purpose of this section is threefold: to characterize the Barnwell Low-Level Waste Disposal Facility (BLLWDF) in terms of operational procedures, site closure, and stabilization procedures; (2) to identify alternatives to these procedures; and (3) to evaluate the impact of these alternatives relative to existing procedures and arrive at conclusions as to the suitability of implementing alternative procedures.

It should be noted, however, that low-level waste (LLW) disposal by shallow land burial is a relatively new and evolving technology. Operating experience at many of the commercial low-level waste (LLW) disposal sites employing shallow land burial has been less than desirable. However as will be noted later in this Assessment, the Barnwell facility has been operated at the forefront of this technology. Taking these factors into account, the staff has noted that the number and range of alternatives available for consideration at the BLLWDF are limited. Where alternatives are available, they will be identified and evaluated as discussed above. The results of the evaluation will be the basis for recommending one of the three major alternatives listed in Sect. 1.2.

2.1 SUMMARY OF CURRENT OPERATIONS

Chem-Nuclear Systems, Inc., (Chem-Nuclear) operates the BLLWDF in Barnwell County, South Carolina, for the disposal of LLW by the shallow land burial method. The facility is about 8 km (5 miles) west of the city of Barnwell, South Carolina, and about 5.8 km (3.6 miles) from the city limit, as shown in Fig. 2.1. It is adjacent to the Barnwell Nuclear Fuel Plant, owned by Allied-General Nuclear Services, and is about 1 km (0.6 mile) from the border of the Savannah River Plant (SRP). The 121-ha (300-acre) site of the BLLWDF is leased from the state of South Carolina.

Low-level radioactive wastes come to Chem-Nuclear at Barnwell from two major sources: nuclear power plants and institutional sources in the United States. The nuclear industry accounts for approximately 75% of the waste by volume, categorized as fuel-cycle waste. Medical, academic, industrial, and research facilities generate the remaining 25%, categorized as non-fuel-cycle waste. Wastes containing 10 nanocuries or more of transuranic nuclides per gram of waste are excluded from the Chem-Nuclear site.

Currently, the Barnwell facility is one of only three commercial LLW disposal facilities operating in the United States. The other two are in Beatty, Nevada, and Richland, Washington.

In 1980, Chem-Nuclear buried a total of 54,222 m^3 (1,936,500 ft^3) of waste with a collective activity of 143,502 Ci (Chem-Nuclear, Barnwell,

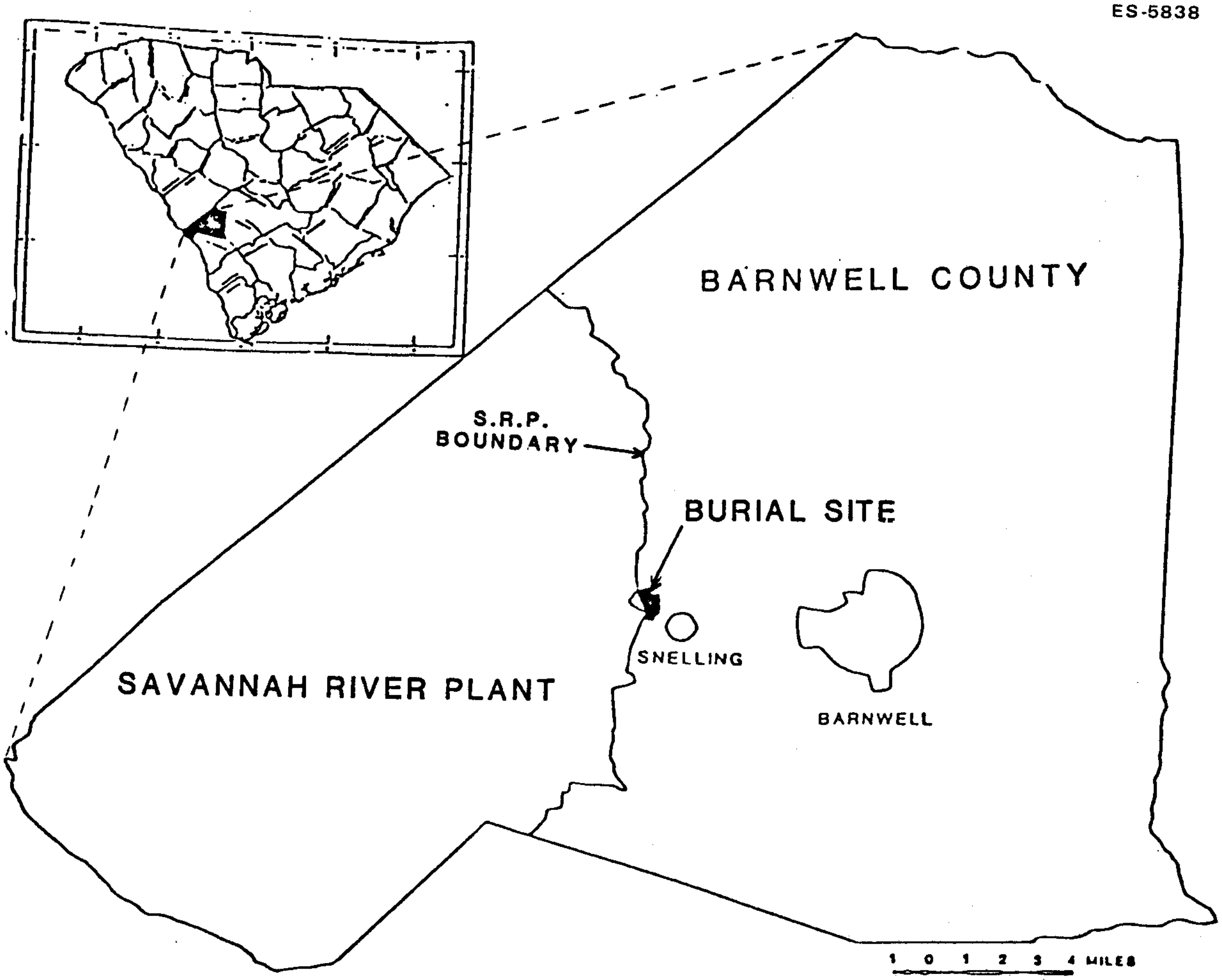

Fig. 2.1. General location of Chem-Nuclear Systems, Inc. Source: South Carolina State Highway Department, General Highway Map, Barnwell County, South Carolina, 1966.

S.C., February 12, 1981. The state of South Carolina has recently placed a ceiling on the annual disposal volume of Chem-Nuclear burial operations which will average about 2832 m^3/month (100,000 ft^3/month) effective October 1981. The average volume in 1980 was 4518 m^3/month (161,375 ft^3month). The existing waste disposal area is shown in the land utilization plan (Fig. 2.2). Approximately 125 customers shipped waste to Chem-Nuclear in 1980. Because of the volume limitations effective October 1981, it is anticipated that not more than 125 customers will use this site.

Radioactive wastes buried at the Barnwell site contain a broad spectrum of materials, ranging from low specific activity to high specific activity and including both fuel-cycle and non-fuel-cycle waste. These wastes originate from hospitals, educational institutions, pharmaceutical

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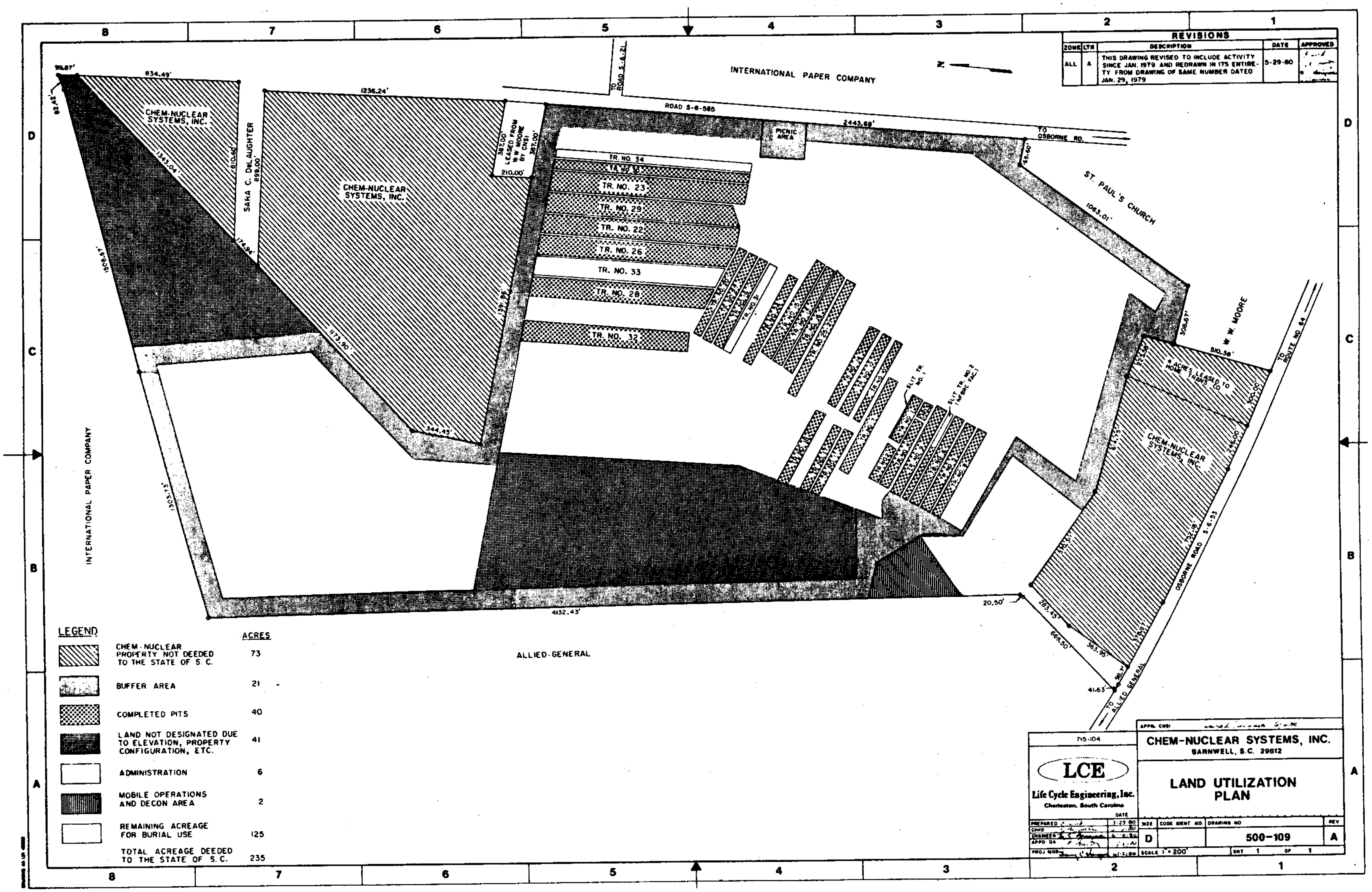

Fig. 2.2. Land utilization plan. Source: CNSI, Barnwell, South Carolina, drawing No. 500-109.

manufacturers, industrial research and production facilities, and the commercial nuclear power industry. The nuclear industry, which produces the fuel-cycle waste, accounts for approximately 75% of the waste by volume. Medical, academic, industrial, and research facilities generate the remaining 25%, categorized as non-fuel-cycle waste.

Non-fuel-cycle radioactive waste consists of paper trash, packing material, protective clothing, broken glassware, plastic sheeting and tubing, animal carcasses, obsolete equipment, and building rubble. Most of this waste has low specific activity. The principal isotopes in the waste are ^{3}H (tritium) and ^{14}C.

Nuclear fuel-cycle waste includes many of the waste categories listed above, as well as higher-activity waste, such as spent ion-exchange resins, filters, filter sludges, solidified liquids, shielding, piping, instrumentation, and control rods. The principal isotopes in the waste include ^{55}Fe, ^{60}Co, ^{63}Ni (from Light Water reactor decommissioning), ^{134}Cs, and ^{137}Cs.

Characterization of both fuel-cycle and non-fuel-cycle radioactive waste typically disposed of at the Barnwell facility is outlined in Table 2.1.

Table 2.1. Characterization of waste in LLW trench[a]

Typical contaminated material	Waste (m^3)	Volume (%)	Specific activity[b] (Ci/m^3)
Fuel-cycle waste			
Solidified liquids[c]	2832	50.0	2.0
Ion-exchange resin[c]	317	5.6	160.0
Filter/demineralizer sludge[c]	498	8.8	10.0
Cartridge filters	35	0.6	20.0
Trash	566	10.0	0.1
Subtotal	4248	75.0	
Non-fuel-cycle waste			
Trash	1416	25.0	0.1
Total	5664	100.0	

[a] Values are based on 1979 values and were estimated by the NRC staff. Actual values were requested from the applicant but were not provided.

[b] Specific activity based on data taken from NUREG/ICR-0570, Vol. 1, Table 2.5.1.

[c] Solidified in concrete, urea formaldehyde, or other approved solidification media.

Source: Oak Ridge National Laboratory.

The volume of LLW buried at Barnwell each year of its whole ten-year operating life (1971 to 1980) is shown graphically in Fig. 2.3.

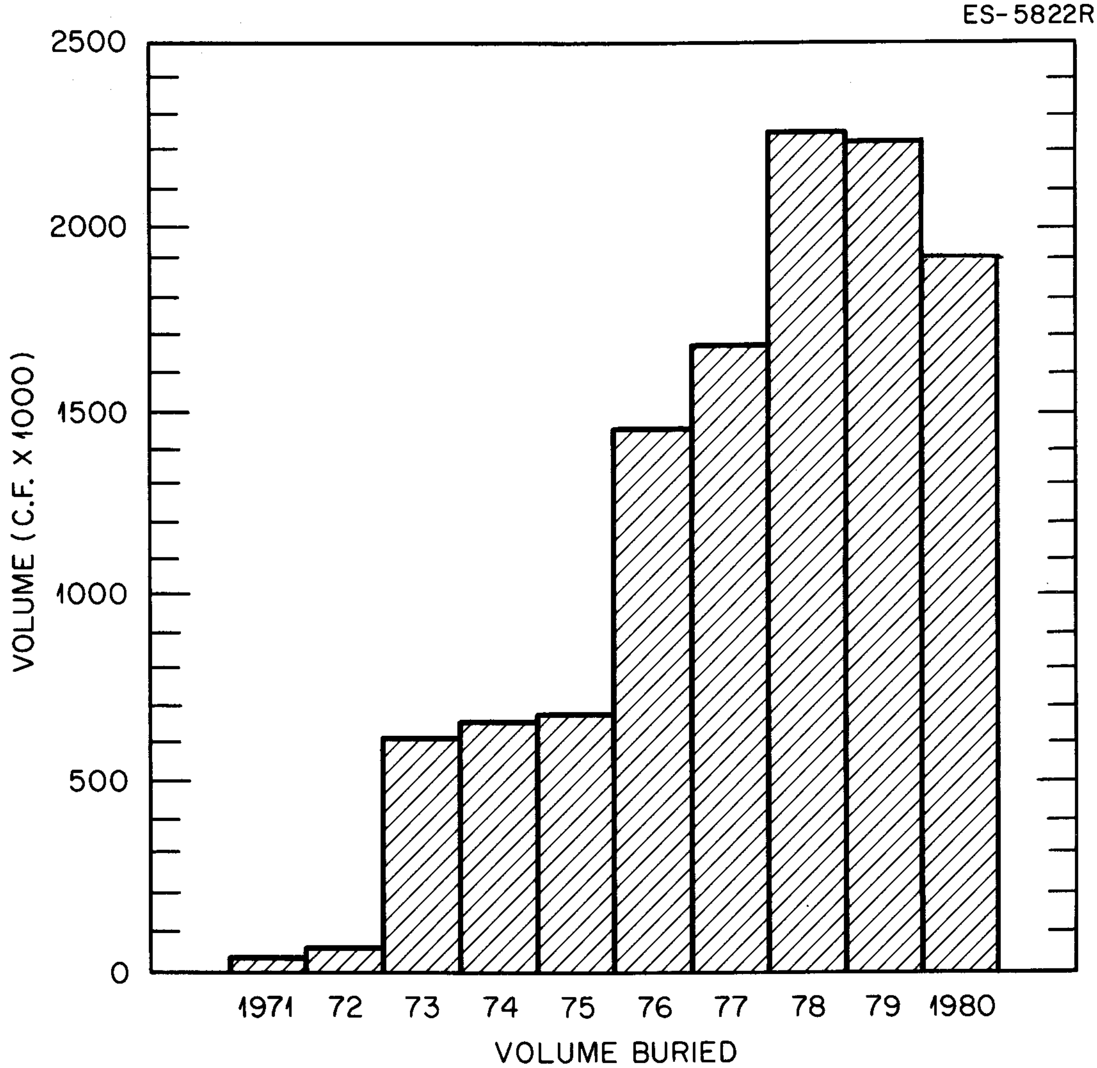

Fig. 2.3. Graphic display of waste volume buried onsite for 10-year operating history at Barnwell. Source: South Carolina Department of Health and Environmental Control, Bureau of Radiological Health, August 1981.

The disposal of LLW consists of the following main operations: receiving shipments, off-loading into trenches, backfilling trenches, compacting, contouring, and final seeding for long-term stabilization. Figure 2.4 is a typical block diagram for the operations at the Barnwell facility. The site facilities include those implied in Fig. 2.4 and administration,

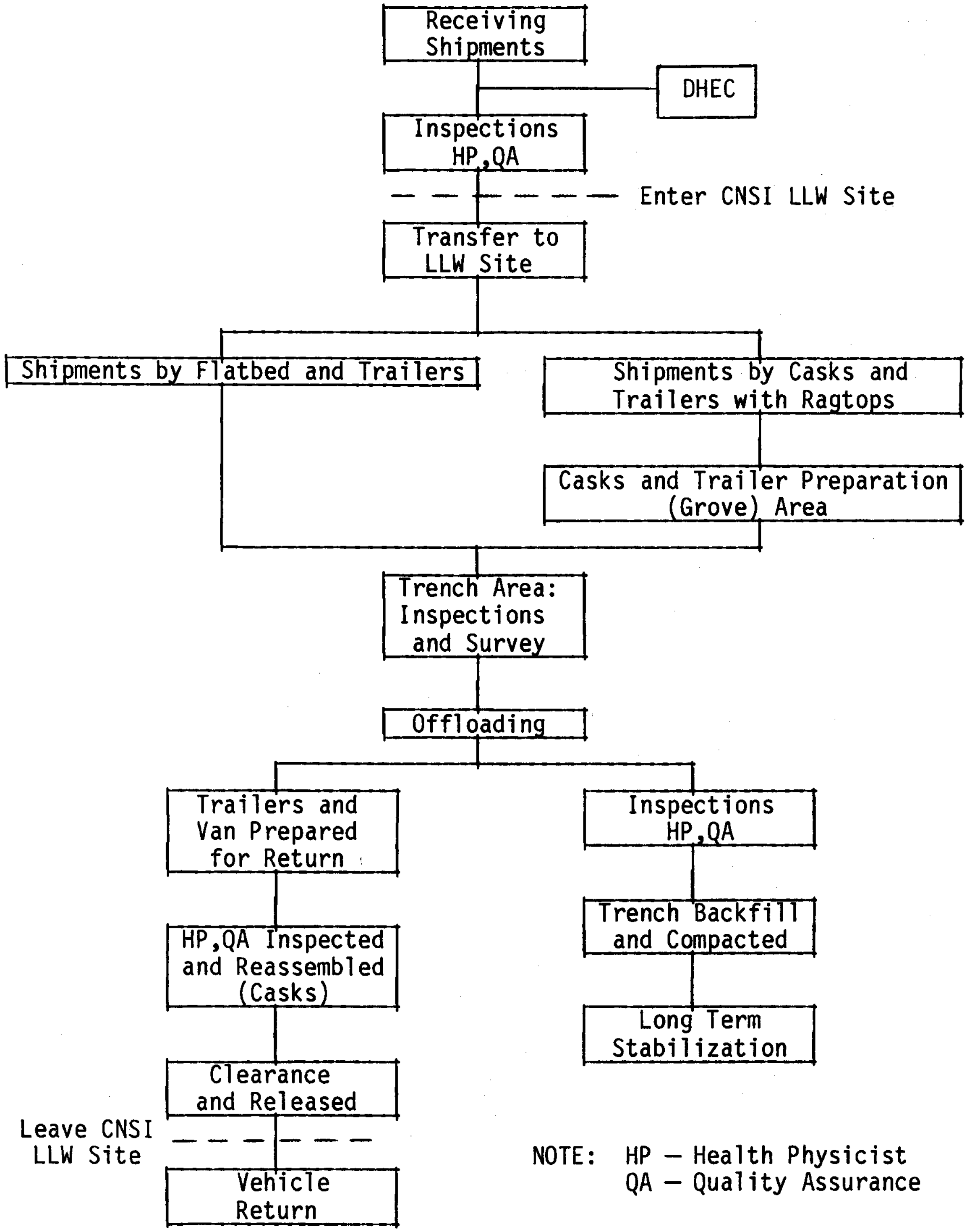

Fig. 2.4. Block diagram for low-level waste facility.

transportation, maintenance, decontamination, and support facilities. Chem-Nuclear normally operates the BLLWDF Monday through Friday between 8:00 AM and 5:00 PM EST, weather permitting. All LLW received must be in agreement with the Prior Notification Plan and Volume Allocation Plan.

2.2 THE ALTERNATIVE OF NO ACTION

If no action is taken, the facility would continue to operate subject to the current requirements of the State of South Carolina, at least until license renewal. The staff considers state personnel to be competent and dedicated and believes that under their surveillance the LLW site is operated in a manner that will protect public health and safety. The staff does not consider that closing the facility is a viable option but does consider that a thorough review of the facility operations and environmental impacts may result in recommended changes that would lessen these impacts over time. Such action is clearly in the public interest, and the alternative of no action must be rejected.

2.3 CURRENT OPERATIONAL PROCEDURES AND ALTERNATIVES

This section describes the principal activities at the BLLWDF. Alternatives to the disposal of radioactive waste by shallow land burial, to a number of steps in the method, and to associated activities are described and evaluated in comparison with the current operation.

2.3.1 Waste packaging requirements and alternatives

Appendix B includes an expanded discussion of regulatory agencies and their roles in regulating the waste packaging and transportation of LLW.

2.3.1.1 Current waste packaging requirements

All shipments received at the Barnwell site must comply with contamination control limits as prescribed in Sect. 173.397 of Title 49 of the *Code of Federal Regulations* (49 CFR Part 173.397) and in the Chem-Nuclear *Barnwell Site Disposal Criteria*.[1] The disposal criteria are noted in the Chem-Nuclear "Standard Operating Procedures — Barnwell Site," approved by the State of South Carolina. All waste packages received at the Barnwell site must comply with all applicable Federal, state, and site-specific regulations. A copy of the operating license issued to Chem-Nuclear by the state may be found in Appendix D.

2.3.1.2 Alternative waste packaging

One viable and economical alternative to existing regulations governing waste packaging would be the use of high-integrity containers. However, waste packagings are determined primarily by DOT and NRC regulations for the shipment of radioactive materials. The State of South Carolina regulations pertaining to waste packaging may be found in Appendix D.

2.3.2 Current transportation methods and alternatives

2.3.2.1 Current transportation methods

This section summarizes the Federal regulations pertaining to the transportation of radioactive material to the BLLWDF.

In transporting radioactive materials, the following basic safety requirements must be met:[2]

1. adequate containment of the radioactive material,
2. adequate control of the radiation emitted by the material and control of contamination, and
3. prevention of nuclear criticality (i.e., prevention of the accumulation of enough fissile material in one location under conditions that could result in a nuclear chain reaction).

General

A major activity associated with operation of the BLLWDF is the transportation of LLW from the site of generation to the disposal site.

Solid low-level radioactive waste is delivered to the site packaged in NRC/DOT-approved shipping containers that comply with the specifications and radiation levels found in 10 CFR Part 71, 49 CFR Part 171-179, and South Carolina Regulation 61-83, effective May 22, 1981. Almost all radioactive waste shipments are transported by semi-trailer truck. However, other transport motor vehicles could include vans, pickup trucks, or automobiles. Waste shipments arrive at Chem-Nuclear in a very large variety of packages, casks, and trailer types. Figure 2.5 shows an LLW shipment from a typical nuclear power plant, packaged in a cylindrical cask.

All shipments, prior to acceptance on the site, are surveyed for contamination and radiation levels. The shipping papers are checked for accuracy and completeness. The packaging is checked for compliance with Chem-Nuclear site criteria, the South Carolina Department of Health and Environmental Control, Bureau of Radiological Health (DHEC) and NRC license requirements, and DOT specifications. The DHEC inspects all shipments, to monitor Chem-Nuclear performance and the shipper's compliance with the DOT and license requirements. Periodically, incoming shipments of LLW are inspected by NRC and DOT auditors.

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Fig. 2.5. Low-level radioactive waste is transported to the Chem-Nuclear waste disposal site at Barnwell.

A more commonly recognized category of low-level radwaste handled by Chem-Nuclear is the power plant waste that is transported in special well-marked casks on "low-bed" trailers.

These casks are made of lead and steel, usually cylindrical in shape with heavy bolt-down covers, and — depending on size — as heavy as 70,000 pounds. Steel tanks, known as liners, are placed inside these casks, and the radwaste, from a power plant for example, is placed inside the liner. The liner is sealed, the cask lid is bolted down, and the load is ready for transport. Source: Brochure provided by Chem-Nuclear.

After shipments are received onsite, they are directed to one of the trenches (normally only one is open, disregarding the slit trench) for off-loading. Fuel-cycle and non-fuel-cycle waste are disposed of in the same trenches. Organic solvents are no longer accepted for burial at the Barnwell facility. After off-loading, the vehicle or piece of equipment that has been in the controlled area is taken to the exit gate and monitored for contamination prior to plant exit (see block diagram, Fig. 2.4).

To support the truck operations, Home Transportation and Tri-State Trucking Companies maintain terminals and drop point locations near the disposal site. Activities are limited to inspection, routine maintenance, fueling, and dispatching of tractors and trailers. Major repair work, overhauls, and decontamination are not included. Because 95% of all truck shipments are exclusive-use, point-to-point shipments, no additional terminal operations are required along routes traveled. The major portion of shipments is handled by Tri-State Trucking Company and Chem-Nuclear vehicles. Hittman Nuclear Corporation, McCormick Trucking, and Home Transportation handle most of the remaining shipments.

Unless there is no practical alternative, all motor vehicles containing radioactive shipments for the BLLWDF are operated over routes that do not go through or near heavily populated areas (EA, p. 66).

Traffic flow and patterns

The total truck traffic resulting from inbound and outbound shipments is approximately 100 trucks per week. This traffic enters and leaves Barnwell County via routes S.C. 41, U.S. 278, S.C. 3, S.C. 64, and S.C. 70, shown in Fig. 2.6. These routes are well maintained two-lane highways through rural areas. All traffic approaching the site must travel over either S.C. 64 from Barnwell or County Road 21. It is, therefore, not necessary for traffic from these entry routes to pass through the center of town. The traffic created by ten years of operation has not had a significant adverse effect on the highway system or populace in this area. There are no congested or heavily populated areas in the Barnwell County or on the entry routes through which Barnwell disposal site traffic must travel.

The frequency of truck shipments is too low to create additional traffic problems on U.S. highways. The sizes and loaded weights of trucks are within the specified limits. Overweight loads with approved special permits may be transported from time to time. Exclusive use of roadways should at no time be necessary; therefore, shipments to or from the BLLWDF should not affect normal traffic flow in any way.

Shipment violation

Routine shipments of radioactive waste materials have been made safely for 25 years in this country. There have been no fatal injuries during the transport and receipt of low-level waste since operation of the BLLWDF began in 1971. All shipping violations of DOT, NRC, or state regulations and/or license requirements result in the appropriate notification of and corrective actions by the shipper.

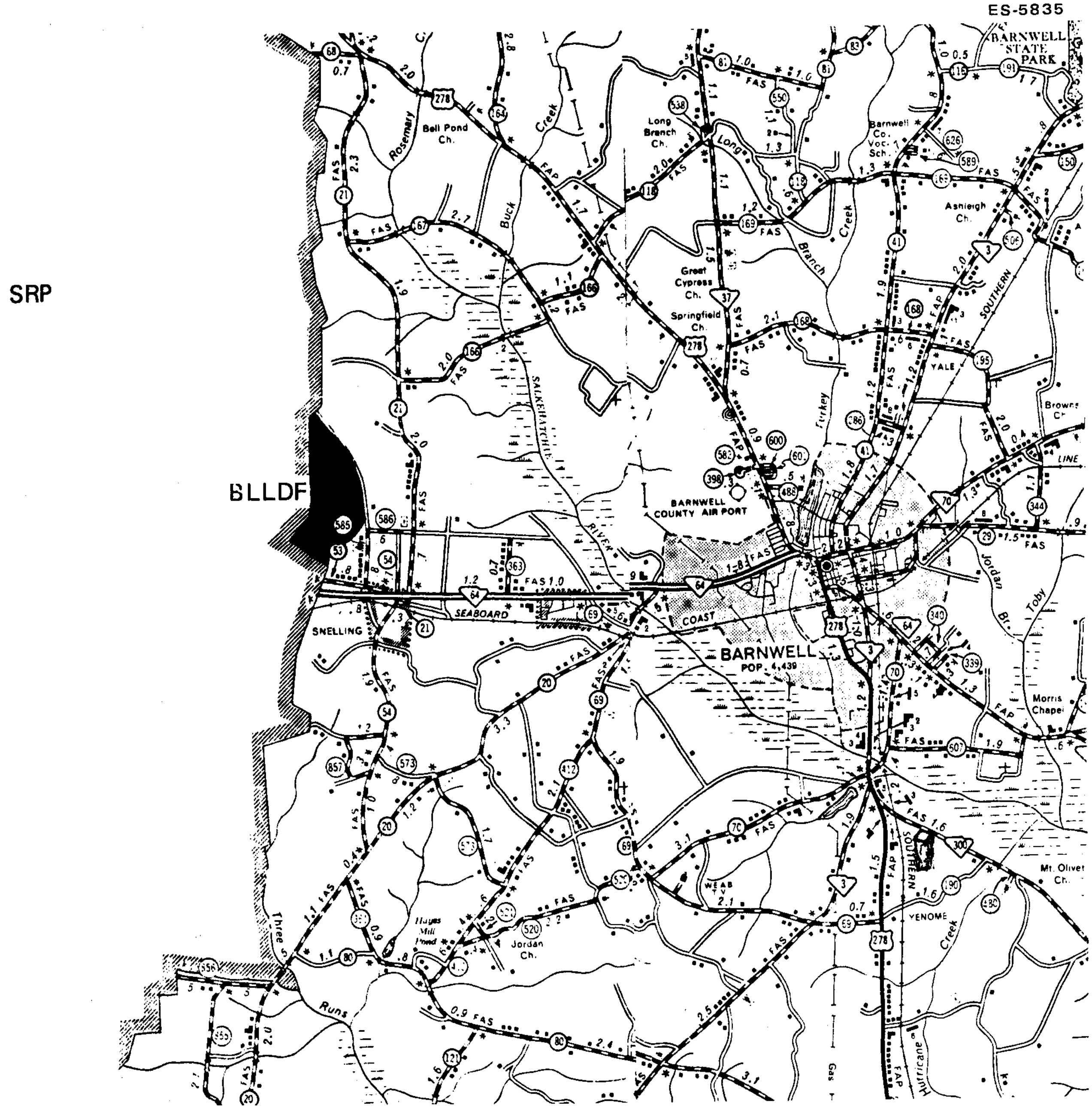

Fig. 2.6. Vehicle route for transportation of radioactive material to Barnwell low-level waste disposal facility. Source: Chem-Nuclear Environmental Assessment.

2.3.2.2 Alternative transportation methods

Alternative 1: Railroad system

An alternative to transportation of LLW by the current method is transportation by railroad lines, because of the nearby location of the Seaboard Coast Line track that serves the SRP and the city of Barnwell. This option would probably require the construction of a spur line and a waste transfer facility near the disposal site and the acquisition of cars for transport of the LLW. Trucks would be required to move the wastes from the transfer facility to the disposal area. The required multiple transfer of the wastes could increase the potential for accidents. The DOT regulations governing carriage of radioactive materials by rail are found in 49 CFR Part 174, "Carriage by Rail."

Only one radioactive waste railroad shipment (a special shipment) has been received for disposal at the Barnwell facility. A major disadvantage of transportation of LLW by railroad is that many generators of radioactive waste are not served by the railroad system.

Alternative 2: Transportation by air

Transportation of LLW by air is a possible alternative to the current transportation method to serve the Barnwell site, assuming that the waste is transferred farther than 500 miles (800 km). The nearest major airports served by the Barnwell facility for passenger-carrying or cargo-only aircraft are Augusta, Georgia, or Columbia, South Carolina, which are approximately 40 and 56 air miles (74 and 104 km), respectively, from the Barnwell disposal site. Therefore, a combination of transportation modes (air and highway freight) would be required for final LLW disposal. No LLW has ever been received at the Barnwell disposal site that had been shipped by aircraft. The DOT regulations governing carriage of radioactive material by air are found in 49 CFR Part 175, "Carriage by Aircraft."

In December 1977, NRC issued a *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes*,[3] which deals in detail with the environmental impacts of various transportation modes for radioactive waste. This document concluded the following:

> For the types and numbers of radioactive material shipments now being made or projected for 1985, there is no substantial difference in environmental impact from air transport as opposed to that of other transport modes (Chapter 4, Tables 4-15 and 4-17 and Appendix I, Table I-9).[3]

Alternative 3: Transportation by water

Historically, water transport modes have been used for shipments of material that are massive or bulky or that do not require exceptionally fast travel. Therefore water transport would qualify as a viable alternative for shipments of LLW. A major advantage of water transportation is the negligible population exposure during transit. The major disadvantages are that (1) not all generators of LLW are served by barge or ship and (2) the nearest navigable water to Barnwell is approximately 48 km (29 miles).[3] No LLW has ever been shipped to or received at the Barnwell site by water transportation modes. The applicable DOT federal regulation governing the transportation of radioactive waste by water is 49 CFR Part 176, "Carriage by Vessel."

The alternative of transportation by barge/ship could be an economical viable alternative to trucking LLW. However, transportation by water (i.e., barge) is not a practical alternative to the current transportation method, because of the lack of service facilities needed by radioactive waste generators, difficulty in timing of shipments of disposal, and dual transportation modes required.

2.3.3 Current waste burial methods and alternatives

2.3.3.1 Current waste burial methods

Chem-Nuclear's current LLW burial method is the shallow land method. This technique utilizes trenches of two basic designs: the "regular" and the "slit" trench.

Regular or standard trenches are much larger than slit trenches and are used for low-specific-activity waste and other low-level waste. Currently, standard trench dimensions have increased over the initial size from 15 m wide by 152 m long to 30 m wide by 305 m long (50 ft wide by 500 ft long to 100 ft wide by 1000 ft long). The trenches are nominally 6.7 m (22 ft) deep. The trench floor slopes gently to one side and to one end in order to collect infiltrated water (if any) at one corner of the trench. Figure 2.7 (ref. 3) is a drawing of a typical burial trench used at Barnwell.

Slit trenches are used for high-curie (mostly nuclear component) waste. The term "slit trench" is used because the trench is very narrow with respect to the standard trenches. This narrow width reduces the "radiation shine" area and, therefore, minimizes personnel exposure to radiation during offloading. Slit trench dimensions are normally 0.9 m wide x 152 m long x 6.1 m deep (3 ft wide x 500 ft long x 20 ft deep).

Barnwell has one active slit trench: a TV-monitored pit for offloading *vertical* casks. Currently, the majority of casks received on the site are the vertical casks. Table 2.2 gives pertinent design information for typical regular and slit trenches.

A surveyor registered in the State of South Carolina verifies and documents the precise location of each burial trench, according to the following construction phases:

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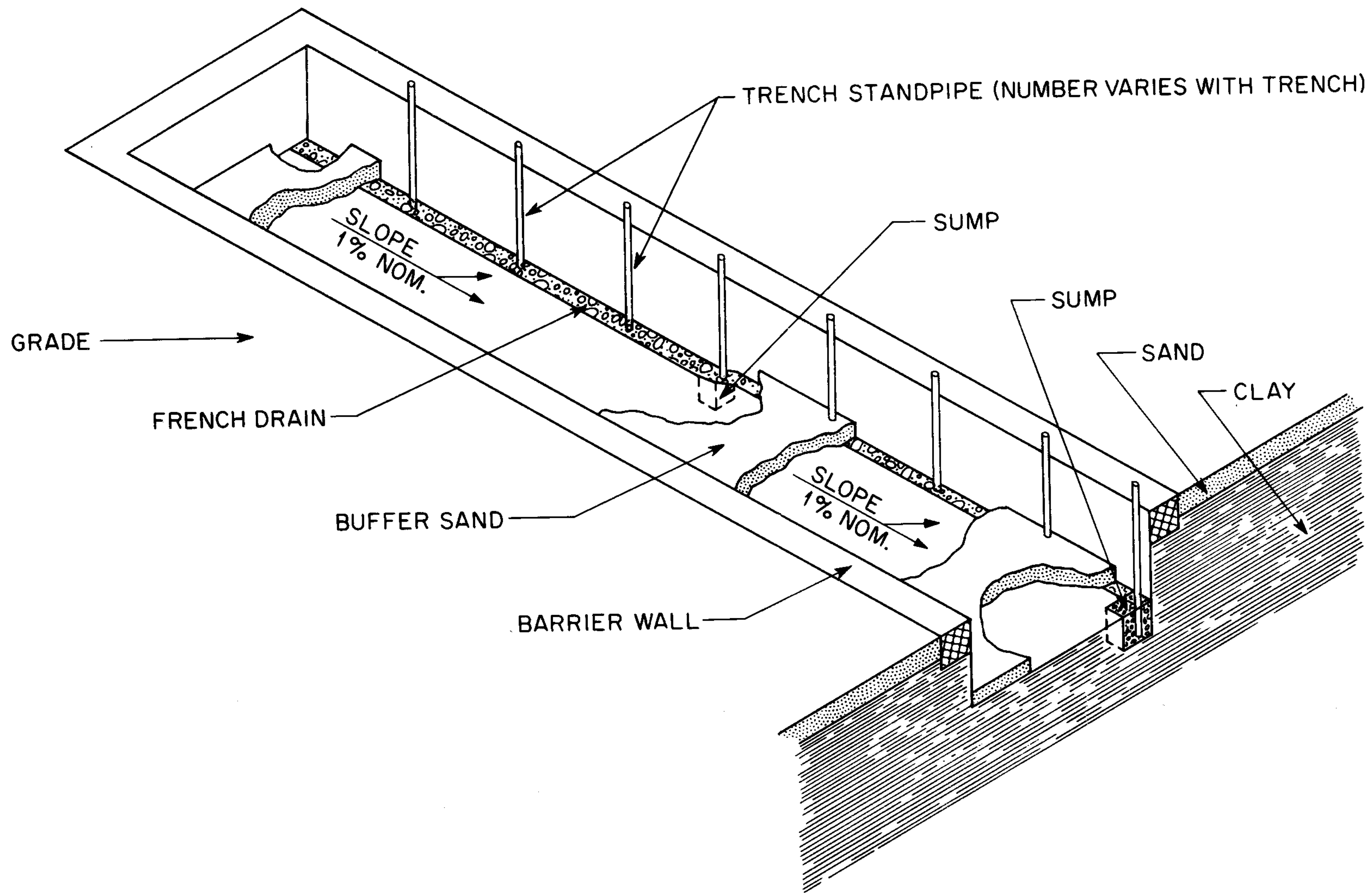

Fig. 2.7. Typical waste burial trench (not to scale). <u>Source</u>: Provided by Chem-Nuclear, Barnwell, South Carolina, Drawing number 500-101, Rev. C.

Table 2.2. A summary of regular and slit trench parameters

Trench type	Dimensions (m)				Slope (%)	
	Length	Top width	Bottom width	Depth	End to end	Side to side
Regular						
Currently approved, now in operation	274–305	30.4	24–30	5–7	0.2–0.4	1
Initial size	122–183	15.2	12–15	5–7	0.2–0.4	1
Slit	61–122	0.9	0.9	5–7	0.2–0.4	1

Source: EA Sect. 3.12, License Particular for Barnwell.

1. prior to trench construction;

2. after completion of trench construction, but prior to any LLW disposal;

3. upon completion of the final grading and stabilization of each trench.

All trench design, details, and construction activities must be approved and inspected by the state.

Trench construction

The *exact* trench location is determined using the site's grid system. This grid system utilizes a baseline and reference points to determine both direction and distance. The reference points used are Savannah River Operations (SRO) monuments SRO 123 and SRO 128 to form a north-south baseline 10° 10' west of magnetic north, with monument SRO 128 being the 0.000,0.000 point. Trenches are spaced a minimum of 2.4 m (8 ft) from each other. Monument SRO 128 is also the elevational reference point for trench floors, capping thickness, and drainage. Prior to excavation of an engineered burial trench, the top (sandy) layer of soil is completely removed from the area. Clay is then brought to the area and compacted to high density to construct an upper barrier wall (see phases I and II of Fig. 2.8). The compacted clay serves two purposes: it prevents the walls from collapsing or caving in, and it ensures that the waste is surrounded by a relatively impermeable barrier. The trench is excavated within this compacted clay area (see phase III). Trench bottoms are excavated to a maximum depth (minimum bottom elevation of 68.5 m (225 ft) above mean sea level. Along the floor's lower side, a 0.6-m (2-ft) French drain is constructed and filled with small stone. Monitoring pipes are installed at 30-m (100-ft) intervals for future sampling capabilities. Two sumps, 1.2 m x 1.2 m (4 ft x 4 ft) and

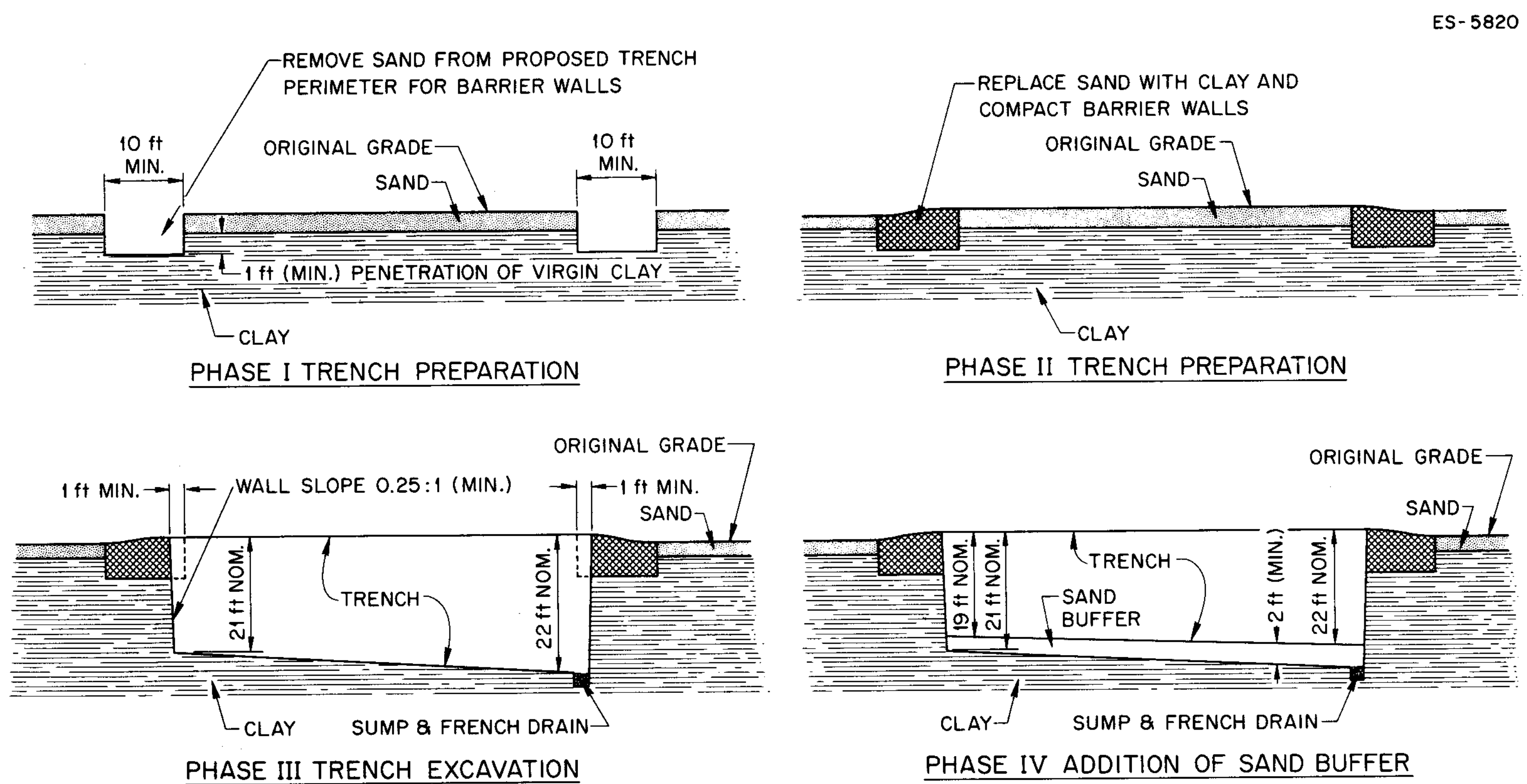

Fig. 2.8. Trench construction details in four phases. Source: Chem-Nuclear drawing number 500-101, Rec. C.

extending 1.2 m (4 ft) below the trench floor, are constructed at 152-m (500-ft) intervals, are filled with stone, and serve as collection points for water. Pervious sand is added to the trench floor for several reasons: (1) to provide a firm and level base for the waste up to 1 m (3 ft) thick, (2) to provide a porous medium for rainfall (into the open trench) to move easily to the French drain and sumps, and (3) to provide a buffer zone for the unlikely rise of the water table (see phase IV of Fig. 2.8).

A minimum of 0.6 m (2 ft) of clay is added, and a 4536-kg (10,000-lb) vibrating compactor is used to accelerate the settling process. Topsoil overburden of at least 1 m (3 ft) is added over the clay.

Burial procedures

All LLW received in acceptable condition is taken to one of the disposal trenches for final deposition. All packages and containers must meet requirements discussed in Sect. 2.3.1. Normally, all waste is buried as received for disposal. License requirements specify certain approved solidification media for fuel-cycle liquids, which further reduce the potential for migration from the trenches (see Sect. 2.3.1.1).

The maximum period that radioactive material or packages can be stored prior to burial is six months from the date of receipt of the package.

Remote hookup and release techniques are utilized routinely in the off-loading operations as a means of minimizing personnel exposure. The site equipment utilized for trench construction and waste burial are 191-, 63-, and 18-MT (100-, 70-, and 20-ton) cranes, motor graders, a dozer, a 4536-kg (10,000-lb) vibrating compactor, a scraper, and miscellaneous backhoes, front-end loaders, and forklifts. All equipment is diesel powered, with the fuel storage tank onsite.

A special burial technique for higher-activity waste uses "toner tubes." Tubular structures are placed in the waste material during filling operations and are utilized at a later date for the off-loading of high-exposure-rate drums. The filled tube is capped with a plug of concrete, the guide structure is removed, and the trench is backfilled and capped, as are all trenches. The advantages of the toner tubes are improved space utilization and minimum personnel exposure.

Waste containing both toxic chemicals and radioactive materials require an independent evaluation of both hazards. If the chemical hazard exceeds the radiological hazard, the waste containing both radioactive material and chemically toxic waste will not be buried at the site without the specific approval of DHEC. Records of hazard evaluation of such wastes performed by Chem-Nuclear are kept for inspection by the department.

Initially, waste packages are emplaced at the higher end of the trench, which is gradually filled toward the lower end. Under current and past operating conditions, waste has not been segregated by container nor at all times are 208-L (55-gal) drums placed in an upright position.

Methods for improving the disposal operation include stacking all drums upright in as closely packed an array as possible. Using vacuum lifters can minimize employee exposure, and drums with higher radiation levels should routinely be placed in the deeper levels of the trenches, with drums of lesser activity being stacked over them as soon as is practicable. This will provide additional shielding and will minimize personnel exposure with little or no loss in efficiency. Similar disposal techniques are recommended for cask liners.

Consideration should be given to methods of filling the interstitial space between both drums and cask liners with sand, gravel, or dirt as each waste layer is placed. This will make eventual trench subsidence easier to repair and less likely to temporarily expose the wastes when subsidence occurs.

Wastes in other than metal containers should be segregated or single layered at the top because the durability and integrity of such containers is uncertain.

The site operator and DHEC should encourage shippers to compact waste shipments to maximum density. This both minimizes subsidence problems and extends the disposal site lifetime.

Site development

In general, all trenches, road layouts, and support facilities are designed to maximize land use and, therefore, increase waste capacity at Barnwell. Drainage ditches are constructed between trenches and along access roads. Clay material and topsoil are stockpiled adjacent to the trenches for sufficient intermediate covering material and final stabilization. Subsequent disposal trench blocks are prepared in a systematic order. Overburden material is used to construct engineered fills at trench areas to a finished grade. Within one year of each trench's completion, grass is seeded over the trench to control erosion.

Surface water control

Completed trenches are sealed, and the cover material is sloped to drain to ditches between trenches. Drainage ditches are constructed along roadways and at appropriate locations to intercept surface runoff from tributary areas. Site grades and drainage ditches are designed to approximate the natural drainage patterns and discharge runoff to the original courses.

The finished grade facilitates rapid removal of surface runoff from the trench area. Runoff is collected in ditches and engineered basins and ultimately released by evaporation and groundwater seepage (Chem-Nuclear, Barnwell, S.C., February 12, 1981). Almost all surface water is contained within the plant boundaries. Section 3.6.1 contains a description of surface water diversion from the burial site. No trenches or embankments will be constructed in aquifer discharge areas. Therefore, changes in the discharge characteristics are not expected.

To minimize infiltration of precipitation, all new trench cappings are overlapped and sloped. Proper surface water management control at burial trenches, in short, consists of minimizing soil erosion and standing water and diverting surface runoff to ditches and evaporation ponds.

2.3.3.2 Alternative disposal methods

As stated at the beginning of this section, the Barnwell facility already exists; therefore, the range of alternatives that are applicable to the site is limited. The staff has considered the following alternative disposal methods:

1. improved shallow land burial,
2. engineered structures,
3. intermediate-depth land burial,
4. mined-cavities disposal,
5. disposal of waste in ocean waters, and
6. waste exhumation.

However, the staff has found only the first two alternatives applicable to the Barnwell facility. A brief discussion of the first two alternatives will be given and the other alternatives will be considered only briefly.

Alternative 1: Improved shallow land burial

Shallow land burial is the major waste disposal method now in use in the United States for all categories other than high-level and transuranic waste. The NRC has sponsored studies[4,5] that rank *IMPROVED* shallow land burial as the most environmentally desirable alternative for LLW disposal. Improvements in shallow land burial, many of which are currently being implemented by Chem-Nuclear, include better disposal trench capping and erosion control, improved trench design, better operational and water management techniques, improved waste forms, and in-situ encapsulation of the buried wastes. Following is a summary of these improvements.

Trench capping and erosion control. Surface erosion requires the proper construction of drainage ditches and diversion dams to control the flow of floodwaters and divert any possible flooding away from the trenches. Erosion from direct precipitation can be controlled by either rock riprap or shortrooted vegetative surface covering.

The single most important factor probably affecting the containment capability of a burial ground is the degree to which groundwater and surface water can contact the waste and subsequently cause migration of the radionuclides.[6] The most effective improvement that could be made on a burial ground would be to place a permanent water-resistant cover over the trenches to restrict percolation of surface water through the waste. Many materials could be used to form this protective cover. Investigations are reported in studies of the more common materials;[7,8] they are clay, soil additives, asphalt, plastic membranes, concrete, and stainless steel.

Improved waste form. The primary reason for improving the waste form is to immobilize the LLW and reduce the potential for radionuclide migration. Because of the applicant's current volume restrictions, waste-volume reduction has become an important subject and is receiving much attention in the nuclear industry. One method of providing an improved waste form would be to incinerate all combustible waste materials before burial. Another method would be to compact all materials.

No liquid wastes are currently accepted at the Barnwell facility, as discussed in Sect. 2.3.1.1, which minimizes potential radionuclide migration.

Improved trench design. Improvements can be made in the trench design to isolate the buried wastes from the environment and minimize any radionuclide migration of LLW. Possible features that could be included in new burial trench designs in different parts of the country, are as follows:

1. Incline the trench bottom to facilitate drainage toward one end and incorporate an appropriately sized sump or drain to allow eventual removal of water that may accumulate in the trench.

2. If the soil, comprising the trench bottom has a low ion-exchange capacity, a minimum of 5 cm (2 in.) of clay may be mixed in the bottom to provide increased ion-exchange capacity. This can probably be accomplished without increasing the tendency of the trench to retain water in the waste region.

3. Cover the trench bottoms with approximately 0.6 to 1.0 m (2 to 3 ft) of coarse sand to assure that any water that accumulates in the trench will be able to flow to the drain without inundating the waste.

4. Provide a drainage ditch at least 0.3 m (1 ft) square along the bottom of one or both walls of the burial trench filled with crushed rock. This will help prevent contact with the water by any water that may infiltrate the trench walls.

5. Provide the sump or drain at the lower end of the trench with a means for sampling and pumping out any accumulated trench water.

6. Process all trench water that has been removed from the sump or drain. This can be done by passing it through an ion-exchange column to remove radionuclides before discharging the water to the environment or by evaporation to prevent its acting as a means of transporting radioactive materials.

Operational improvements. Several improvements in the operation of a shallow land disposal facility will minimize future maintenance and/or water infiltration problems. The following operational improvements apply to all shallow land disposal facilities, such as Barnwell, which implemented many of these improvements.

Inclement weather. Cease off-loading during inclement weather.

Subsidence. Subsidence may be minimized by filling the interstitial spaces between waste containers with dry sand before covering the trenches. Filling voids with sand, in conjunction with improved waste forms, will minimize settling of trench covers. This method would help reduce long-term maintenance and site repair operations.

Stacking. Drums and inner cask liners may be stored to help decrease accidents, reduce subsidence problems, and increase the overall waste/trench volume ratio.

A "Vacuum drum" lifter can be used for unloading drums into the burial trenches to keep drums upright and provide a more orderly method for stacking drums into burial trenches. Efforts can be made to stack LLW of higher concentration at or near the bottom of trenches and LLW of lower concentration near the top of trenches to minimize personnel exposure during offloading.

Personnel training. A formal personnel training program should be maintained to improve communications and minimize human errors at a disposal facility. Chem-Nuclear does maintain such a program, which is approved by the State of South Carolina at the Barnwell facility.

Water management control. Water management control was discussed in Sect. 2.3.3.1.

Alternative 2: Engineered structures

Engineered structures could be established at the Barnwell site. Advantages of an engineered structure over a LLW facility are better monitoring for leaking radioactivity, isolation from water infiltration, and potential for retrieval of waste at a later time.

A structural disposal facility built of reinforced concrete would have durability and fire resistance. Concrete has been estimated to last at least 1000 years in contact with moist soil.[9] Both covered and exposed structures are considered alternatives that could be built at the existing site.

The easiest and least expensive structure to build and to fill with waste would be an exposed structure with its foundation at grade. An engineered structure could also be constructed such that the roof is at or near grade and so that the completed facility would present only a low mound or be even with the surface grade. This would be technically suitable where the water table is consistently low enough to be below the resulting level of the floor and the adjoining soil has good drainage.

Inside the structural disposal facility, the 208-L (55-gal) waste drums would be stacked upright by a forklift or an internal traveling crane.[6] When a cell became filled, it would be closed with a wall of poured-in-place, reinforced concrete tied to the rest of the structure with reinforcing bars.

The radioactive waste containing higher radiation levels, which is the smaller fraction of the waste, would necessitate handling techniques different from those used for the lower-radiation-level wastes. One possible method involves little basic change in the cell design beyond installing a remotely operated bridge crane, and another possibility involves sunken storage vaults in the floors of the cells.

There are many uncertainties in evaluating potential environmental effects of disposal in engineered structures. Durability of containers, likelihood of reclamation efforts, and long-term structural integrity are some of the difficult areas to assess.

Experience concerning waste disposal in engineered structures is very limited, and the staff considers them less desirable than burial options because of the uncertainties involved.

Alternative 3: Intermediate-depth land burial

An alternative to shallow land burial is burial at greater depth. The generic concept for deeper burial has been referred to as "intermediate-depth" burial.[10] The concept is essentially the same as shallow land burial, except that an additional 10 to 15 m (30 to 50 ft) of clean soil cover is applied over the buried wastes. A schematic diagram of the concept is shown in Fig. 2.9. The extra cover would be provided for by appropriate site selection, perhaps excavating the site to the desired depth before digging the disposal trenches, or by reclaiming suitable sites, such as former strip mines.[6] However, the alternative is not applicable to the Barnwell site because of the proximity of the water table to the land surface (see Sect. 3.6.2).

Alternative 4: Mined-cavities disposal

Disposal in cavities in geologic formations has been categorized into disposal in natural caverns and in mined chambers. Mines generally considered include both existing nonproductive mines and new excavations made explicitly for LLW disposal.[6] However, the staff does not consider this alternative feasible at the Barnwell site and feels that further discussion of this alternative is not warranted.

Alternative 5: Disposal of waste in ocean waters

The ability of the oceans to accommodate waste disposal depends on the physical form of the waste, the disposal site, and restrictions imposed on transport of the waste to the disposal site. Because there exist variations and uncertainties in the suitability of the ocean for waste disposal, extensive additional research is needed to assure adequate containment of many possible waste types.

As a result, current regulatory restrictions do not allow direct ocean dumping and projectile penetration of the sediments. Therefore, at present, ocean disposal is not a viable alternative for the disposal of LLW.

Alternative 6: Waste exhumation

A final alternative waste disposal method is exhumation of buried waste from a commercial facility and transfer of the exhumed waste to a storage site operated by the Federal government (i.e., DOE).

This alternative would be considered only in situations where site/waste stabilization and long-term care are not sufficient to ensure the continued capability of the site to provide adequate containment of the buried waste. This alternative does not apply to the Barnwell facility.

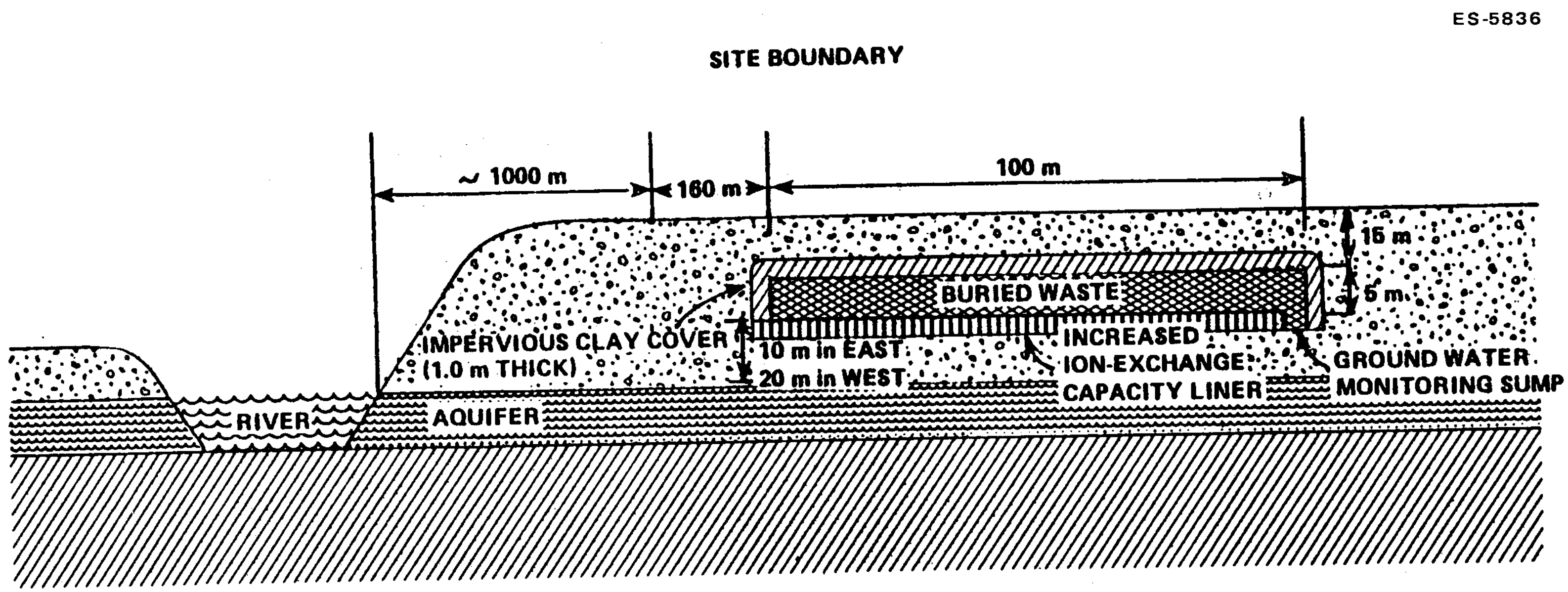

Fig. 2.9. Typical schematic of deeper burial facility. Source: Ref. 1, NUREG/CR-0680, Fig. 3.2.

2.3.4 Waste inventory records and alternatives

2.3.4.1 Current waste inventory records

Radioactive shipment record forms

The Chem-Nuclear facility has standardized the radioactive shipment record form to be used for all shipments of radioactive material received at the site. This form is shown in Fig. 2.10. All sections of the form shall be completed prior to shipment. This form transmits all applicable information concerning the wastes from the shipper to the burial ground operator. For each waste package, the specific information required is contained in the main body of the form. Information concerning the entire shipment (shipper, receiver, number of items, total activity, total volume, etc.) is shown at the top of the form. Instructions are printed on the reverse side of the form. Improperly prepared radioactive shipment record forms delay the acceptance or refusal of the shipment. Copies of the form are retained by the shipper, the receiver, and the carrier. The radioactive shipment record form is used by the burial site operator as a major part of the waste inventory records.

Location and future retrieval

Waste inventory records are accurately recorded and maintained, showing contents, radiation levels, and storage location for each LLW shipment. Shipments are described and recorded, and permanent computerized records are maintained on duplicate magnetic tapes (Chem-Nuclear, Barnwell, S.C., February 12, 1981). The exact location of each burial trench is defined by use of the grid system discussed in Sect. 2.3.3. A granite trench marker is installed to accurately mark the location of each trench and record its contents. Total cubic footage, amounts of special nuclear material and source material, total activity, and completion date are etched into the marker.

Because of Chem-Nuclear's permanent methods of documenting waste inventory, future retrieval (if necessary) would be possible for exhumed LLW at the Barnwell facility; all LLW previously characterized for burial could be located exactly.

Current waste inventory records are well documented and maintained; therefore, discussion of alternative waste inventory records is not warranted.

2.3.5 Monitoring procedures and alternatives

2.3.5.1 Onsite radiological monitoring program

A summary of the current radiological monitoring program is presented in Table 2.3. Locations of the TLD monitors and wells used in the program are shown in Figs. 2.11 and 2.12.

ES-5841

(1) FROM Company Name ____________
Address ____________
Contact ____________
(2) Phone # ____________
TO ____________

CARRIER ____________
DRIVER SIGNATURE ____________
DATE AND TIME RECEIVED ____________

BARNWELL WASTE MANAGEMENT FACILITY

Operated by: CHEM-NUCLEAR SYSTEMS, INC.
P. O. Box 726, Barnwell, South Carolina 29812
(803) 259-1781
RADIOACTIVE SHIPMENT RECORD FORM

Page ______ of ______

(4) Volume Allocation No. ____________

(5) Shipping Date ____________
Shipment No ____________
Type of Cask ____________
Trailer No ____________
LINER SERIAL # ____________

CNSI USE ONLY

Arrival Date ______ AS# ______
Date Time Buried ______ B ______
Radiation Readings ______ Weight ______
Trench # ______ LOC ______ WCC ______
Total Personnel Exp ______ mR
Project # ______

(3) — (a) Description of Materials	(b) Total # of Pkgs This Shipment	(c) Total Activity This Shipment	(d) Total Volume This Shipment	(e) Type Containers This Shipment
( ) RADIOACTIVE MATERIAL, LSA, NOS ( ) RADIOACTIVE MATERIAL, NOS ( ) RADIOACTIVE MATERIAL, SPECIAL FORM NOS ( ) RADIOACTIVE DEVICE, NOS, RAD MATERIAL		mci	cu ft	

(6) Item No.	(7) Radio-nuclide each container	(8) Percent Abundance Each Nuclide	(or) Activity Each Nuclide (mCi)	(9) Physical form	(10) Chemical form	(11) Waste Description	(12) U-235 (grams)	(13) U-238 Th-232 (pounds)	(14) Disposable Container Weight (pounds)	(15) Disposable Container Volume (Cu. Ft.)	(16) Container Spec.	(17) RADIATION LEVELS Disposable Container Surface	Package Surface	3 Ft. (TI)	(18) Removable Contamination Package Surface (a) DPM/100cm²(B-Y)	(19) Trans-port Group	(20) Label Used
(21) TOTAL																	

(22) ( ) Yes ( ) No THIS VEHICLE IS CONSIGNED EXCLUSIVE USE. LOADING AND UNLOADING MUST BE ACCOMPLISHED BY CONSIGNOR OR CONSIGNEE OR HIS DESIGNATED AGENT

(23) IMPORTANT "This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation

Signature ____________
Company ____________ Date ____________

(See Reverse Side for Instructions for Completing This Form)

(24) "Certification is hereby made to the South Carolina Department of Health and Environmental Control that this shipment of low-level radioactive waste has been inspected in accordance with the requirements of South Carolina Radioactive Material License No 097 as amended, and the Nuclear Regulatory Commission's License No 46-13536-01 as amended and the effective Barnwell Site Disposal Criteria within 48 hours prior to shipment, and further certification is made that the inspection revealed no items of non-compliance with all applicable laws, rules and regulations."

Date ____________ By ____________
Title and Organization ____________
Telephone No ( ) ____________

Form No CNS-201 (4/80)

White Accompany Shipment, Yellow Customer, Pink Carrier

Fig. 2.10. Standardized radioactive shipment record form. <u>Source</u>: From Chem-Nuclear Systems, Inc., Barnwell, South Carolina Form No. CNS-201 (4/80).

Table 2.3. Current monitoring plan

Sample description	No. of locations	Type	Media	Frequency of analysis	Type of analysis
External gamma	40	Continuous	TLD	Quarterly	Exposure
Atmosphere (onsite)	5	Continuous	Particulate filter	Weekly (collected daily)	Gamma isotopic, gross beta, gross gamma
			Charcoal cartridge	Weekly	I-131
Soil (onsite)	10	Grab		Annual	Gamma isotopic, HTO
Vegetation (onsite)	10	Grab		Annual	Gamma isotopic, HTO
Water springs (offsite)	3	Grab		Annual	Gamma isotopic, HTO
Site boundary wells (onsite)[a,b]	10	Grab		Semi-annual	Gamma isotopic, HTO
Cluster or monitor wells (onsite)[b,c]	50	Grab		Quarterly	Gamma isotopic, HTO
Observation sumps (onsite)[d]		Grab		When available	Gamma isotopic, HTO
Potable wells (onsite, offsite)[b]	5	Grab		Quarterly	Gamma isotopic, HTO

[a]Water level measured quarterly.
[b]All well samples are collected following pump down and recharge period.
[c]Water level measured monthly.
[d]Sumps checked monthly.

Air monitoring

Routine air monitoring is performed continuously at five onsite locations (see Table 2.3), utilizing a continuous air-sampling device equipped with a particulate filter designed to trap and hold airborne particulates of a type encountered in the breathing zone, followed by a charcoal cartridge for collecting radioiodine. The samples are removed weekly and analyzed for specific radionuclides by gamma-ray spectrometry for gross alpha and beta activity, and the charcoal filter is analyzed for ^{131}I. Currently, atmospheric samples have been taken at five locations; however, a revised onsite monitoring plan is currently being implemented under which ten permanent monitoring locations have been identified along a line marking the boundaries of the site. The new locations are shown in Fig. 2.13, and the planned sampling schedules are shown in Table 2.4. Additionally, during onsite disposal operations, portable air stations are being installed adjacent to the operating disposal trench to monitor the immediate area for increased air activity and, thus, to evaluate exposure risk to operating personnel.

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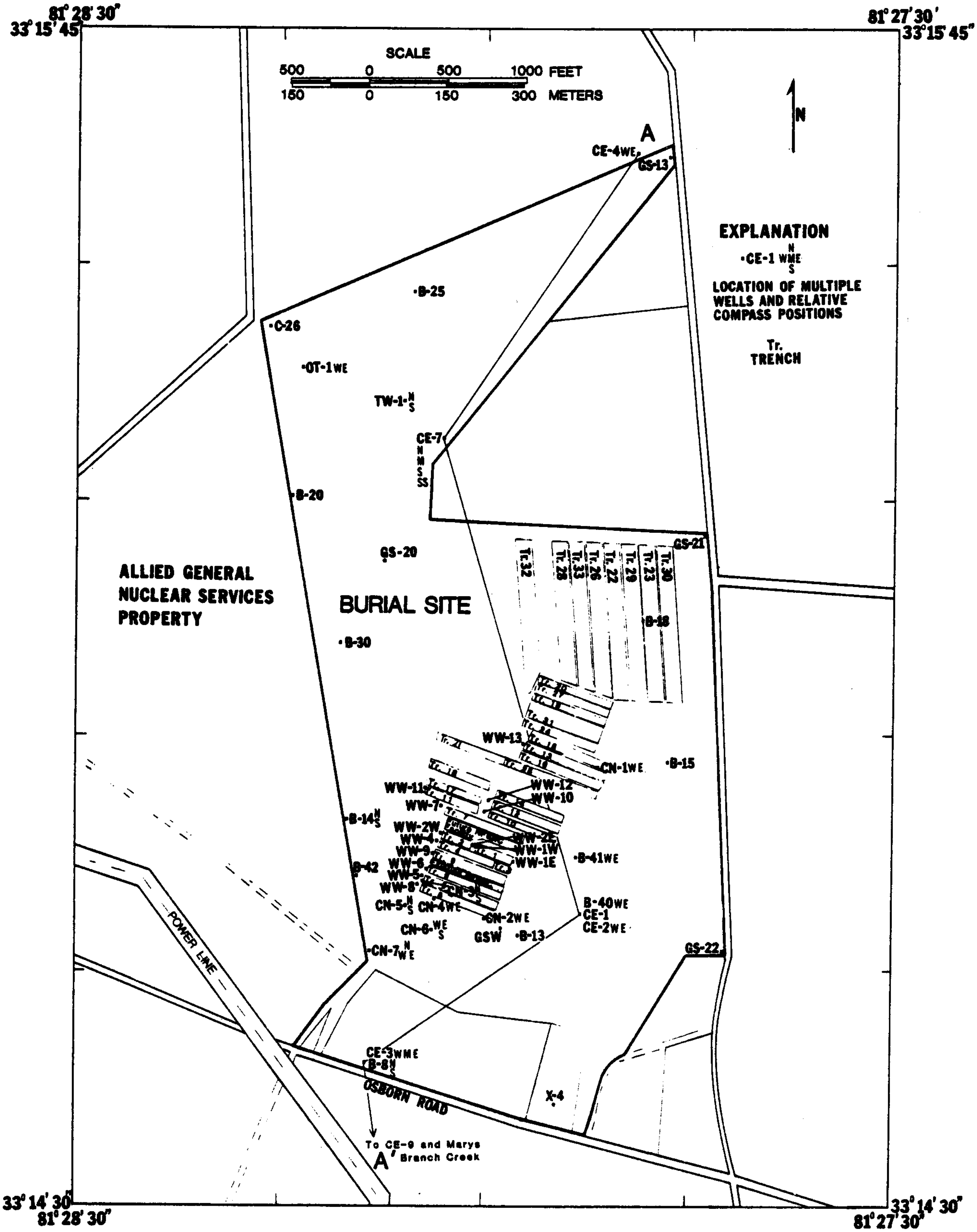

Fig. 2.11. Current environmental monitoring locations. •, wells.

ES-5860

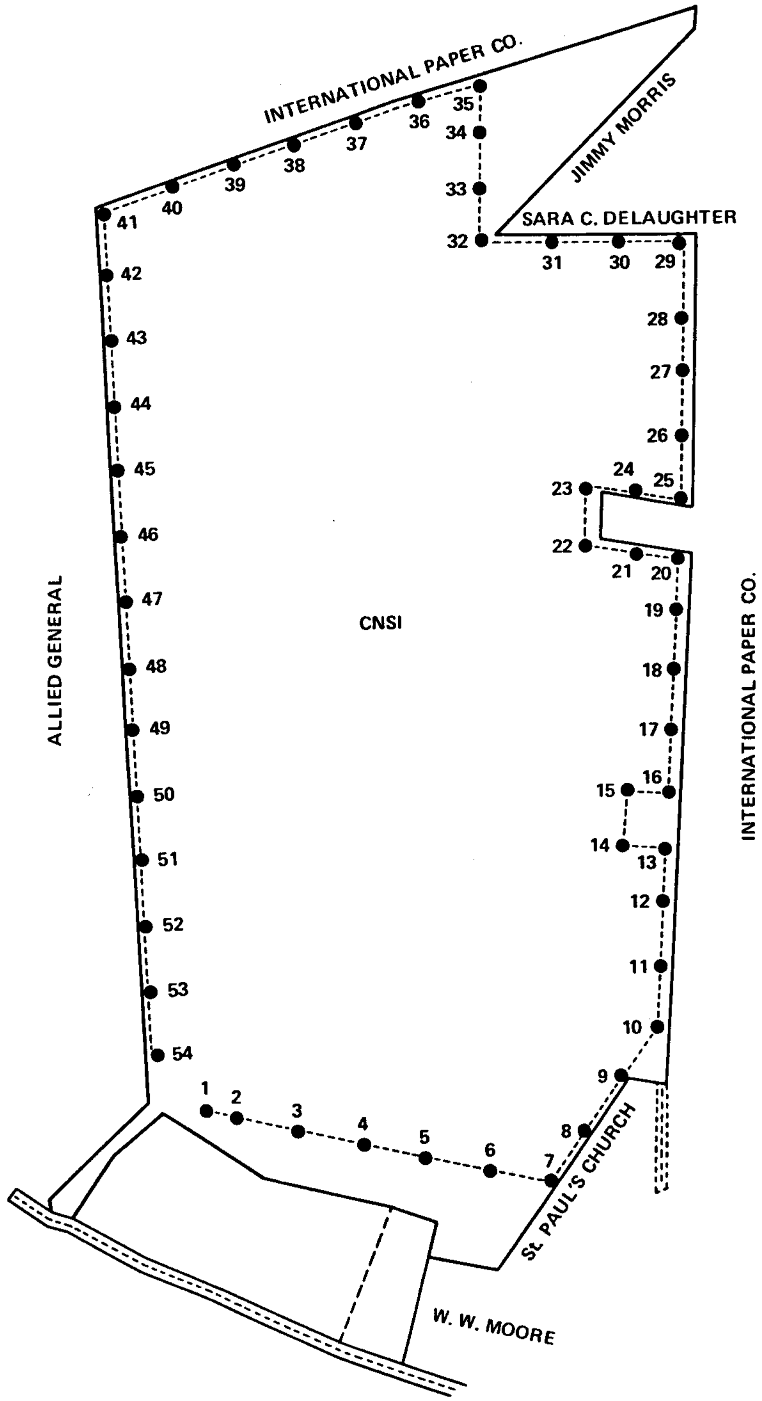

Fig. 2.12. Locations of TLD monitors. <u>Source</u>: *Preliminary State Stabilization and Closure Plan for the Barnwell Low-Level Radioactive Waste Disposal Facility*, Chem-Nuclear Systems, Inc., Columbia, S.C., May 1980.

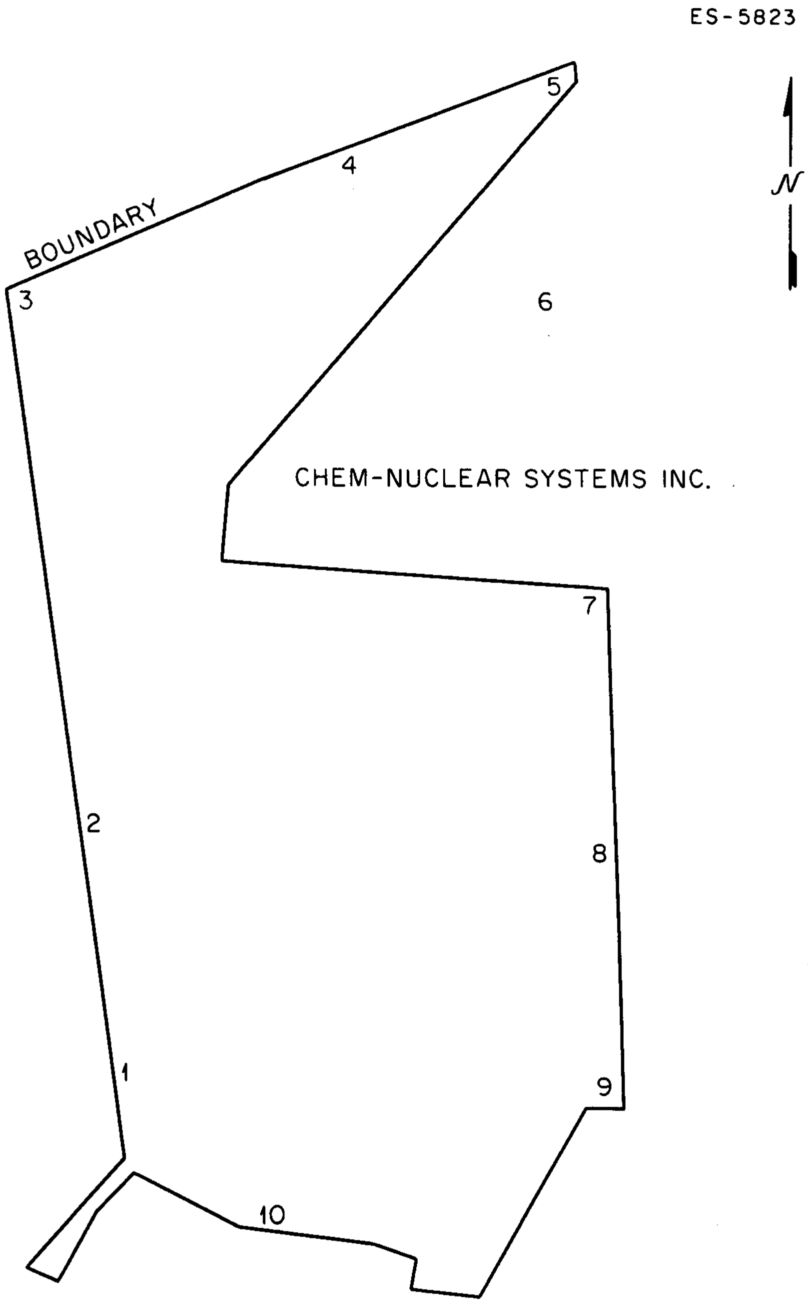

Fig. 2.13. Planned permanent environmental monitoring locations (# = permanent onsite sampling locations).

Table 2.4. Onsite sampling schedule

Sample description	No. of locations	Type	Media	Frequency of analysis	Type of analysis
External gamma	40	Continuous	TLD	Quarterly	Exposure
Atmospheric	10 (site) 1 (offsite)	Continuous	Particulate filter Charcoal cartridge	Weekly Weekly	Gamma isotopic, gross alpha/beta, Iodine-131
Soil	10	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Vegetation	10	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Site boundary wells[a]	10 (3 per location	Grab		Semi-annual	Gamma isotopic, Gross alpha/beta HTO
Monitor wells[b]	50	Grab	Water sediment	Quarterly	Gamma isotopic, gross alpha/beta, HTO
Observation[c] sumps	40 (estimated)	Grab	Water sediment	Quarterly (when available)	Gamma isotopic, gross alpha/beta, HTO
Potable wells	3	Grab		Quarterly	Gamma isotopic, gross alpha/beta, HTO
Pumping station	3	Grab		As required	Gamma isotopic, gross alpha/beta, HTO

[a]Water level measured quarterly.
[b]Water level measured monthly.
[c]Sumps checked monthly.

Groundwater and surface water monitoring

The primary transport pathway for contaminants to man from an eastern disposal site is via surface water or groundwater. Currently, scheduled grab-type samples are taken at wells used for potable water supply, at site boundary or ring monitoring wells, at monitoring wells located within 7.6 m (25 ft) of trenches 1 through 13, and at cluster monitoring wells strategically located throughout the site. Cluster wells are defined as one "deep" well to the water table and one well to each of the sand levels greater than 1 m (3 ft) encountered in drilling the "deep" well. The number of locations and the frequencies of sampling are shown in Table 2.3. All samples are analyzed for specific radionuclides by gamma-ray spectrometry and for tritium by liquid scintillation counting.

A revised plan for onsite monitoring of surface water and groundwater is shown in Table 2.4. In this plan all site boundary wells will be the cluster-type monitoring wells. These wells will be placed at permanent locations, shown in Fig. 2.13. In addition to water sampling, sediment samples will be collected at the trench monitoring wells and from the observation sumps. In addition to the gamma-isotopic and tritium analyses, the water and sediment samples will also be analyzed for gross alpha and beta activity. This revised plan was required by DHEC to make data available in a more timely manner as a consequence of the expanded operations of the Barnwell facility. In addition, the DHEC has not relinquished its own monitoring responsibilities.

Soil and vegetation

Soil and vegetation samples are collected at ten locations onsite and analyzed annually for gamma-emitting isotopes and tritium (see Table 2.3). In the revised sampling program under implementation, the soil and vegetation samples will be taken at the permanent locations shown in Fig. 2.13, and they, in addition to the gamma-isotopic and tritium analyses, will be analyzed for gross alpha and beta radioactivity. The planned revisions are shown in Table 2.4.

External gamma monitoring

Currently, the external gamma is routinely monitored by TLD monitors at 54 locations along the site boundary. The locations are shown in Fig. 2.12. In the revised monitoring program, the TLD monitors will be placed at the outer perimeter of the ten permanent monitoring locations and at 92-m (100-yd) intervals along the security fence that encompasses the site restricted area (see Fig. 2.13).

2.3.5.2 Offsite radiological monitoring program

A summary of the current offsite monitoring program is shown in Table 2.3, combined with the onsite sampling program.

Air monitoring

No routine air monitoring is currently conducted off site of the BLLWDF by Chem-Nuclear. In the revised program under implementation, a control air sampling station will be established at the Barnwell County Airport for offsite air quality assurance. The DHEC has accumulated considerable offsite data; their records indicate that no activity attributable to the Barnwell site has been observed.

Groundwater and surface water

The offsite groundwater and surface water sampling program as currently conducted is limited to three offsite natural springs and two potable-water wells (see Table 2.3) to determine whether there is any intrusion of radioactivity into the groundwater table at offsite locations. In the revised offsite monitoring plan (currently being implemented), in addition to the three springs, seven offsite potable-water wells, four monitor wells, and surface water at Mary's Creek will be sampled, as shown in Table 2.5, to develop data to supplement site-boundary permanent well data for monitoring of possible seepage of radioactivity to the local groundwater. All samples will be analyzed for gross alpha, gross beta, tritium, and gamma-emitting isotopes.

Table 2.5. Offsite sampling schedule

Sample description	No. of locations	Type	Media	Frequency of analysis	Type of analysis
Offsite wells	4	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Offsite water springs	3	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Offsite potable wells	7	Grab		Annual	Gamma isotopic gross alpha/beta, HTO
Offiste open water, Mary's Creek Grist Mill	2	Grab	Water sediment	Annual	Gamma isotopic gross alpha/beta, HTO
Offsite soil (water springs)	3	Grab		Annual	Gamma isotopic gross alpha/beta, HTO
Offsite vegetation (water springs)	3	Grab		Annual	Gamma isotopic gross alpha/beta, HTO

Soil and vegetation

Currently, offsite soil and vegetation sampling is not performed routinely. Under the plan being implemented, shown in Table 2.5, soil samples will be taken following the selection pattern for the offsite monitor and potable-water wells. In addition, sediment samples will be taken downstream of the outfall of the three natural springs. Vegetation samples will also be taken following the selection pattern for the monitor and potable-water wells.

External gamma

To monitor the direct immersion radiation exposure from external gamma, a control station using TLD data shall be established at the same location as the offsite air sampling station (at some public building in the town of Barnwell). Currently, no offsite monitoring for external gamma is performed.

2.3.5.3 Other monitoring programs in the BLLWDF area

In addition to the monitoring program carried out by Chem-Nuclear, extensive environmental sampling is performed in the site area by neighboring nuclear facilities (SRP and Barnwell Nuclear Fuel Plant) and by the DHEC.

The state of South Carolina maintains a network of sampling stations around the site area. A permanent air monitoring station is maintained near the site picnic area (Fig. 2.8), as well as at numerous onsite wells. Monitoring programs at neighboring nuclear facilities add a valuable supplement to the current monitoring program provided by Chem-Nuclear.

2.3.5.4 Alternative monitoring systems

The capability of the new, improved monitoring system makes the consideration of alternative monitoring systems unnecessary.

2.3.6 Current measures to minimize public radiation exposure and alternatives

Public radiation exposure from the BLLWDF may result from one of three mechanisms: atmospheric transport of contaminated material to offsite receptors; hydrologic transport of radionuclides to offsite water bodies; and intentional or unintentional removal of contaminated materials by individuals to offsite locations. Exposure of the public through atmospheric transport may occur through direct inhalation of contaminated material or through ingestion of food contaminated by the processes of transport and deposition. Similarly, exposure resulting from hydrologic transport may be direct (ingestion of radionuclide-contaminated water) or indirect (consumption of food contaminated by uptake of radionuclide-contaminated water).

Both the licensee (Chem-Nuclear) and DHEC have developed control measures to minimize the probability of offsite exposure through any of the three mechanisms identified above. These control measures were reviewed by the staff and have been determined to be adequate to minimize the potential for public exposure to radiation from the BLLWDF. Key control measures which led to this determination include:

- o Development of operational procedures for receipt, storage and disposal of LLW. These procedures are in-place in the "Standard Operating Procedures--Barnwell Site" and are regularly improved and expanded by the licensee;
- o Requirements for waste form and packaging developed by DHEC, NRC and DOT;
- o Inspection of incoming shipments to assure compliance with packaging requirements. Inspections of incoming shipments are carried out by the licensee and DHEC on a daily basis;
- o Confinement of licensed operations to within a restricted area surrounded by security fencing;
- o Radiation monitoring of all personnel and vehicles entering or leaving the restricted area;
- o Design, construction and closure of waste trenches to minimize the potential for releases during operation as well as over the long term;
- o Onsite and offsite monitoring of air and water pathways by the licensee and DHEC as discussed in Section 2.3.5;
- o Auditing of various site operations on an annual basis by an independent Chem-Nuclear QA component to assure compliance with site and corporate procedures; and
- o Inspection of the site and overall facility operation by DHEC and NRC to assure compliance with license conditions.

The staff, in taking a recent licensing action on the Barnwell facility, concluded that the existing controls have been effective in preventing offsite exposures through a review of the licensee's compliance history and monitoring data. There are no recommendations at this time as to alternative measures.

2.3.7 Current measures to minimize occupational exposure and alternatives

The potential for occupational exposure to radiation at an LLWDF such as Barnwell is present in any number of situations: physical contact with waste containers during off-loading; handling of contaminated equipment; proximity to the radiation "shine" of operational trenches; and others. The Barnwell facility operates under a system of administrative controls, protective equipment and facilities and monitoring devices designed to keep occupational exposure as low as reasonably achievable. This system is implemented at the site through on-site management and is supported and augmented at the corporate level by a Safety Review Board. Major control mechanisms in place at the Barnwell LLWDF include the measures discussed in Section 2.3.6 in addition to the following:

- Training of all personnel in basics of radiation safety with additional training as warranted by the job category. Retraining given at annual intervals, as necessary;

- Requirements for all employees working with radioactive materials to wear protective clothing;

- Presence of health physics technicians at all waste handling operations to monitor and control exposure;

- Establishment of administrative limits for radiation exposure;

- Utilization of a slit trench and remote handling equipment for disposal of higher activity waste;

- Development of shipment-specific handling procedures and use of Radiation Work Permits for handling and disposal of special waste shipments;

- Solicitation of exployee suggestions for reducing exposure levels; and

- Maintenance of exposure records for all site employees and regular review and analysis of such records.

The staff has reviewed onsite employee exposure records and has determined that exposures are well within the limits set in 10 CFR Part 20 and that progress has been made by the licensee toward reducing exposure of occupational categories that have historically had the greatest exposure. Chem-Nuclear's control measures for occupational exposure are therefore considered by the staff to be adequate and there are no recommendations for alternative measures.

2.3.8 Current site stabilization techniques and alternatives

As waste is deposited in a trench, sandy topsoil, which has been removed during trench preparation, is backfilled to eliminate void spaces between waste packages and to serve as shielding for site personnel. A clay layer is added and compacted to accelerate the settling process. This procedure is followed until the trench is filled with waste. After the trench is filled, additional soil overburden is placed over the clay layer. The total overburden of topsoil and clay is approximately 1.5 m (2 ft of clay and 3 ft of soil). Overburden thickness typically ranges from 1.5 to 4.3 m (5 to 14 ft). To provide adequate drainage, the trench cap is contoured and the adjacent ground is sloped away from the trench. Within one year of the completion of the trench, a grass cover is established to ensure stabilization and to control erosion.

The staff inspected the site on February 12, 1981, and the completed trenches appeared quite stable. They all have a good grass cover, and the contouring and sloping done to promote surface drainage has remained intact. The site stabilization techniques being used are effective. Consequently, no alternative stabilization techniques are suggested. Stabilization techniques do not pose a major problem for continued operation of the waste disposal facility.

2.4 SITE CLOSURE AND STABILIZATION

In Sect. 1.5 the staff identified the need to review site closure and stabilization plans. This staff review follows and discusses performance objectives already established, but not necessarily implemented, so that staff considerations and concerns will be clearly evident.

2.4.1 Performance objectives

The NRC and the DHEC have both issued an amendment to the operating license for the BLLWDF, which requires that 16 performance objectives (Conditions) be met by Chem-Nuclear to ensure an acceptable site stabilization and closure plan (See Appendix D, item 78).

Condition 1 deals with the burial of all waste in accordance with the requirements of the license. Chem-Nuclear currently holds two licenses to operate the BLLWDF, from two licensing agencies: the DHEC and the NRC. The NRC license specifically addresses the possession of special nuclear material.

According to the requirements of the license issued by the DHEC, no burial operations are performed in a newly excavated trench until all phases of the trench design have been approved by the DHEC. The DHEC currently has assigned a full-time official to the facility to inspect incoming shipments and burial operations.

In addition to inspections made by the State of South Carolina, periodic unannounced audits are made by the NRC. These inspections assure continued compliance with the license conditions.

Condition 2 deals with the decontamination, dismantlement, and disposal of all structures, equipment, and materials that are not to be transferred to the custodial agency. Details related to the decontamination and dismantlement of site structures, equipment, and materials are given in "Preliminary Site Stabilization and Closure Plan for the Barnwell Low-Level Radioactive Waste Disposal Facility."[11]

Chem-Nuclear has committed to allocating sufficient space in the last existing trench for the disposal of site structures, equipment, and materials. The current maximum volume needed is estimated to be 1133 m^3 (40,000 ft^3).

A cost evaluation has been determined for site decommissioning. Details related to this evaluation are discussed in Sect. 2.4.2.

Condition 3 states: "Document the arrangements and the status of the arrangements for orderly transfer of site control and for long-term care by the government custodian. Also document the agreement, if any, of State or Federal governments to participate in, or accomplish, any performance objective. Specific funding arrangements to assure the availability of funds to complete the site closure and stabilization plan must be made."

The property that Chem-Nuclear is currently utilizing for the disposal of low-level radioactive waste was purchased by Chem-Nuclear but has been transferred and is now owned by the State of South Carolina. Chem-Nuclear has a long-term lease agreement with the State of South Carolina for the use of this land (see Appendix G).

One year before the anticipated transfer of site control to another person, government, or agency of a government, Chem-Nuclear will prepare and submit to the DHEC the final version of the Site Stabilization and Closure Plan. The Preliminary Site Stabilization and Closure Plan will be reviewed every five years.

Currently, no agreements have been made for the State or agencies of the Federal government to participate or accomplish any performance objective.

Specific funding arrangements to assure the availability of funds for site closure and stabilization will be discussed in Sect. 2.4.2.

Condition 4 states: "Direct gamma radiation from buried wastes should be essentially background."

Background radiation in the State of South Carolina is on the order of 10-12 $\mu R/h$.[11] To assure that gamma radiation does not contribute significantly to background levels, surveys have been conducted over completed trenches. However, initial surveys conducted were not adequate to document significant increases in background radiation levels, because of the sensitivity levels of the instruments used.

After these initial surveys, Chem-Nuclear obtained an instrument in 1974 that has increased sensitivity to perform the required surveys. However, many of these surveys were invalidated because of the extreme sensitivity of the instrument and the proximity of the surveys to open trenches.

As active trenches move further from covered trenches, more reliable results will be obtained, and potential surface radionuclide dispersion can be identified. These surveys should be conducted at specified time intervals and, over longer time intervals, will confirm if the condition has been met, and the procedures and methodologies used should be documented. Results from these surveys should be forwarded to the DHEC at specified time periods.

Condition 5 requires that Chem-Nuclear demonstrate that the rates of release of radionuclides through air, groundwater, and surface water pathways are at or below acceptable levels.

Potential radionuclide release mechanisms are discussed in Sect. 2.4.3. Details related to existing systems for monitoring air, groundwater, and surface water quality are in Sects. 2.3.5 and 4.1. Possible impacts-related migration of radionuclides in the media mentioned above are discussed in Sect. 4.2.

Condition 6 deals with relinquishing the site in a manner that is suitable for surface activities during custodial care and is at the same time compatible with the plans of the custodial agency for future use of the site.

Physical conditions that may affect post-decommissioning surface activities of the site will be discussed under Condition 8. No definitive or conceptual future plans for the site have been specified. The State of South Carolina should give Chem-Nuclear some preliminary conceptual plans for what it intends to do with the site to carry out the license condition.

Condition 7 requires that Chem-Nuclear demonstrate that all trench bottom elevations are above water table levels, taking into account the complete history of seasonal fluctuations.

Before burial operations began at the site, Chem-Nuclear gathered geological and hydrological baseline data related to the site. Since the initial collection of hydrological baseline data, Chem-Nuclear has continuously monitored water level data on the site. From this data, the staff has determined that all completed trench bottoms are at least 1.5 m (5 ft) above the maximum level of the water table that could be expected including seasonal variations. However, hydrographs for each well indicating all previous historical water level changes should be constructed and kept current. Potentiometric maps should be compiled quarterly, indicating past and present seasonal variations in the water table level (see Sect. 3.6.2).

Condition 8 deals with possible geomorphological, hydrological, and climatological factors which might affect trench integrity and long-term site stability.

Chem-Nuclear helps ensure trench integrity by constantly reviewing state-of-the-art techniques and guidelines related to trench design and waste burial methods. Geomorphological, hydrological, and climatological factors which might affect trench integrity are discussed in Sect. 2.4.3.

One of the primary factors affecting long-term stability is the final topography of the site. Current site closure and stabilization plans call for returning the site to as natural a state as possible.

As stated in the discussion related to Condition 6, the State of South Carolina should indicate to Chem-Nuclear what it proposes to do with the site after closure.

Condition 9 requires that trench markers be in place, stable, and keyed to benchmarks and that identifying information be clearly and permanently marked.

Details related to the grid system and to the emplacement of trench and information markers may be found in ref. 11.

Condition 10 deals with the compilation and transferral of complete records of all past site operations to the State of South Carolina for use during custodial care.

Records related to Chem-Nuclear operations are extensive. However, records, reports, procedures, and drawings on every phase of these operations routinely have been and are either being maintained by Chem-Nuclear or forwarded to the DHEC. A routine site receipt and burial activities report is submitted to the DHEC each month. Environmental sampling results are submitted quarterly. Other monitoring data and information related to trench operations are also sent to the DHEC routinely.

Condition 11 requires that Chem-Nuclear establish a buffer zone around the site, the width to be decided on a site-specific basis, which will be transferred to the custodial agency. The purpose of this buffer zone would be to provide sufficient space to assure long-term stability (i.e., stabilize slopes if required, allow for modification of surface water management features, assure that activities on adjacent property do not compromise site stability, etc.) and to provide working space for implementation of mitigating measures should they be required in the future.

Chem-Nuclear established, in 1973, a buffer zone of at least 30 m (100 ft) in any direction from past, current, or future burial operations. To date, this buffer zone comprises an 8.5-ha (21-acre) tract within the perimeter of the 95-ha (235-acre) exclusion area that has been deeded to the State of South Carolina. The boundaries but not the width of the buffer zone may be adjusted to accommodate future changes in the utilization of the site property. Chem-Nuclear has a registered surveyor responsible for maintaining the integrity of the buffer zone and preventing trench encroachment in the zone.

Condition 12 provides for a secure, passive site security system (e.g., a fence) that requires minimum maintenance.

Chem-Nuclear has installed a fence 2.4 m (8 ft) in height to implement security of the site's exclusion area. The fence surrounds the exclusion area, with access and egress controlled by security personnel through a main gate. The fence is constructed of galvanized steel mesh with three horizontal strands of barbed wire extending outward from the top at a 45° angle. The fence and gates are inspected daily by site security personnel.

Prior to site closure and stabilization, the fenceline will circumscribe the land to be transferred to the custodial agency. The fence will be standing within 1 m (3 ft) of the property line on the site's buffer zone, and Chem-Nuclear will perform any required maintenance to the fence before property transferral.

Condition 13 requires that the site be stabilized in a manner to minimize long-term environmental monitoring requirements and to develop an environmental monitoring program that is consistent with the custodial agency plans for long-term care and maintenance. Chem-Nuclear is reviewing its environmental monitoring program and doing so in conjunction with the DHEC. Details regarding implementation of the new environmental monitoring program are in Sect. 2.3.5.

Changes in the environmental monitoring program may be required in the future. However, before any changes are implemented, the approval of the DHEC is required.

The method and schedule for turning the environmental monitoring program over to the custodial agency will be outlined in the final Site Stabilization and Closure Plan. Chem-Nuclear believes that close coordination with the custodial agency will be required to prepare the plan for the transition period, to maintain consistency in the environmental data, and to enable the custodial agency to continue the monitoring program established by Chem-Nuclear.

Condition 14 requires that Chem-Nuclear, "Investigate the causes of any statistical increases in environmental samples which have occurred during operation and stabilization. In particular, any evidence of unusual or unexpected rates or levels of radionuclide migration in or with the groundwater must be analyzed and corrective measures implemented."

Chem-Nuclear has completed its environmental laboratory and research facility on the site. This should enable Chem-Nuclear to analyze environmental monitoring samples with a significant reduction in time and enable Chem-Nuclear personnel to readily identify any statistical increase in monitoring results. If statistical increases are identified by Chem-Nuclear personnel, Chem-Nuclear is required to report such increases within 48 h to the DHEC.

The term "statistical increase" has not been formally defined by either Chem-Nuclear or the DHEC. Currently, what constitutes a statistical increase is purely subjective and arbitrary. As stated in Sect. 4.1.1.1, the monitoring data acquired over the life history of the site are not currently in a trended form to make any type of comprehensive assessment, but are being compiled for that purpose. Once the data are compiled in a trended form, Chem-Nuclear and the DHEC should define what constitutes a statistical increase. This statistical increase should be identifiable by two or more independent parties assessing the same data and should be reproducible with respect to time.

No mitigatory measures to be implemented have been documented by Chem-Nuclear in the event that any evidence of unusual or unexpected rates or levels of radionuclide migration in the groundwater is detected.

Condition 15 states: "Eliminate the need for active water management measures, such as sump or trench pumping and treatment of the water, to assure that wastes are not leached by standing water in trenches. Passive systems are preferred. Engineered methods of intercepting contaminated groundwater or directing groundwater should also be passive."

The primary radionuclide release mechanism for an LLW site in the eastern United States is probably groundwater. Groundwater may come in contact with buried radioactive waste by groundwater intrusion (rising water table), percolation of meteoric (derived from the atmosphere) water and/or snow melt, and overflow (trapping of percolating water resulting from low-permeability sediments forming the trench bottom).

Chem-Nuclear has intended to preclude the possibility of groundwater intrusion by constructing trench bottoms at least 1.5 m (5 ft) above the maximum water table (allowing for seasonal variations). Chem-Nuclear has also intended to preclude the occurrence of percolation and overflow in its trench design and construction of trench caps. Details related to trench design and trench cap may be found in Sect. 2.3.3.1. The final proposed topography for the site is designed to minimize percolation.

Although evidence of water in completed and capped trenches has been found at the Barnwell facility, the evidence has been sporadic. Trench sumps found to contain water on one occasion have, on subsequent sampling, been found not to contain water. Moreover, analyses of water samples taken indicate that the concentrations of radionuclides are orders of magnitude lower than the concentrations found in trench waters at other low-level waste disposal facilities. Taking this information into account, the staff has concluded that adherence to Condition 15 at the Barnwell LLWDF has been successful to date and is likely to continue being so for the foreseeable future. However, there is not sufficient data on the long-term (i.e., hundreds of years) performance of low-level waste disposal facilities to assure that elimination of active water management, as required by Condition 15, can be guaranteed. Therefore, the staff recommends that the condition be periodically reevaluated by the state of South Carolina against the results of site monitoring.

Condition 16 requires that Chem-Nuclear evaluate the current and zoned activities on areas adjoining the site, determine their impact (if any) on the long-term stability of the site, and take reasonable action to minimize any resultant effects. Currently, no activities on areas adjoining the site indicate the potential to affect the long-term stability of the site. Additionally, there is no zoning on the adjoining areas, nor is there any planned.

2.4.2 Financial guarantees for closure and for long-term care

Chem-Nuclear is presently required by the terms of the operating licenses issued by both NRC and DHEC to establish financial assurances for closure and stabilization, as well as for the long-term care of the Barnwell site. These financial requirements attempt to ensure that the licensee provides sufficient financial assurances to protect the public health and safety and the environment. The financial assurance requirements also ensure that the licensee and the waste generators who use the Barnwell disposal facility, and not the state's taxpayers, will assume responsibility for closure and long-term care of the site. Additionally, the state approached the financial assurance requirement for long-term care through the use of two legal instruments; a lease, and a trust agreement. The lease, was negotiated between the state as landowner of the site and Chem-Nuclear as leasee. The lease and its subsequent amendments (see Appendix G) to provide the specific terms and conditions for the licensee to establish financial assurances for closure and for long-term care of the site.

In addition to the lease arrangement, the state and the licensee are both party to a trust agreement which establishes a trust for the holding of closure funds collected by the licensee. Trustees manage the funds to ensure that the funds are safely invested to protect their value against inflation.

Funding for final site stabilization, closure and decommissioning

As was previously noted, the licensee is required by the conditions of its license to establish financial assurances for closure, stabilization and decommissioning of the site so that the state's taxpayers are not held financially responsible for closure in the event of licensee default. A trust fund has been set up so that the funds for closure are properly managed and invested. As of March 1981, Chem-Nuclear had deposited $1,726,700 in the trust funds. The monies will be invested and used to carry out the requirements established for final site stabilization, closure, and decommissioning. The licensee provided a closure estimate to the state of approximately $1,470,000 in 1980 dollars. After a review of these figures, DHEC found this estimate of closure costs to be consistent with the known site conditions.

2.4.2.1 Alternative funding methods for final site stabilization, closure, and decommissioning, and post-long-term maintenance and environmental monitoring

This evaluation of alternative funding methods was concerned with two primary considerations: The type of funding program and the timing of cash flows. A brief discussion of each follows.

Types of Financial Assurances

1. No Funding Program

Using this regulatory alternative, the state would not establish any funding requirement of waste licensees for financial responsibility for closure and long-term care. Without such a funding program, either the custodial care regulatory agency or the site owner would be responsible for all costs incurred. The staff did not consider this alternative, because the state of South Carolina has already implemented financial assurance requirements for both closure and for long-term care through the use of lease and license conditions.

2. Escrow Account

An escrow account is another method of assuring funds for closure. With such an arrangement, cash or marketable securities in an amount equal to or greater than the estimated costs of closure are deposited into a special account held by a financial institution. An escrow serves as a receptacle for the deposit of goods or property until the licensee satisfactorily completes closure activities. The institution holding the funds is the depository, and an escrow agreement sets out the terms and conditions by which the materials can pass to either party. An escrow that functioned as an assurance for closure and postclosure costs would involve a binding agreement with terms and conditions that would specify that upon failure to meet prescribed closure activities, the fixed amount necessary for all closure activities held in escrow would pass to the appropriate government agency.

3. Surety Bonds

A surety bond provides a cosigner on an obligation. The surety bonding relationship involves three parties whereby the surety company for a fee, promises to the obligee (the government agency) that the principal (the licensee) will perform specified activities (in this case all closure and decommissioning activities). The surety company takes on a possible liability for a profit. If a bonded operator were to default on his obligation to carry out closure activities then the bonding company must provide the remainder of the guaranteed funds to the holder of the bond (the regulatory agency) to have the work successfully completed. Upon satisfactory completion of closure activities by the operator, the bonding arrangement can be terminated and the bonding company is then released from its obligation.

4. Self-insurance

Self-insurance refers to an arrangement whereby the operator agrees to perform the closure activities, and finance the activities out of his own resources, such as cash working capital. In effect, it is an alternative offering no additional assurance other than the licensee's legal obligation to perform closure activities which are required as a condition of the license. The legal obligation pursuant to the license exists regardless of any separate contract or lease, whereby the operator agrees to perform closure. A major shortcoming of using self-insurance occurs when the licensee may not have sufficient funds to meet his responsibilities at a time when no revenues are generated from the operation. In the case of default, the government agency would have to obtain a legal judgment based on its contract with the licensee and then execute its judgment over whether the licensee has sufficient assets available. The staff believes such a regulatory approach is not acceptable.

5. Shared Insurance Pool

A shared insurance pool consists of disposal facility operators (and possibly, operators of other fuel cycle facilities) to make payments to such a fund. The pooling of closure funds could help to ensure closure performance even if a particular facility operator were to default. The agency would act in a fiduciary capacity for the public because if the operator defaulted on performance of required closure activities then the pool would pay for the cleanup out of the shared funds. Determination of the proper premiums to charge the members of the pool would be difficult, since the pool administrator would have to estimate the liklihood of nonperformance or partial performance and calculate the magnitude of the fund required to complete the closure activities.

6. Surcharge on Waste Generators and Collection of Funds into a Sinking Fund

Requiring a licensee to impose a surcharge on a cubic foot or meter basis on the users of the site to recover closure expenses is a mechanism that is currently in use in several states with LLW disposal sites. Funds are collected on a capacity basis from waste generators, and the funds are then deposited into an interest bearing account so they keep pace with inflation. Currently, this method is required of Chem-Nuclear under the terms and conditions of the lease between themselves and the state. With such a mechanism, the burden of financial responsibility for closure of a site is borne by the waste generators who use the waste disposal service.

Another variation on this financial assurance mechanism would be the attempted development of a sinking fund that was funded on a "perpetual basis." That is, the sinking fund would be set up so that the collected funds would be invested and earn interest at a greater rate than inflation, therefore ensuring that interest is always generated at a rate that is greater than inflation and that funds are available in perpetuity to provide for long-term care of the site. However, with present high levels of inflation relative to the interest that could be earned on such a fund, there is a high probability that the funds generated would be insufficient.

7. Trust Fund

A trust fund is a well-established mechanism for holding property and applying it, or income from it, to a particular purpose. The state of South Carolina and Chem-Nuclear have already developed a trust fund to provide for closure costs. A trust is an arrangement whereby one party holds and may even manage funds or property for the benefit of another. In this case, the beneficiary of the trust fund would be the state or federal government. The trustee of the closure trust would be a bank or some financial institution. The terms of the trust would define the investment responsibilities of a trust.

The Timing of Cash Flows

A variety of timing alternatives exist for determining when the funds are to be received. The least stringent method of assuring that sufficient funds would be available for care of the LLW disposal site would be to require the licensee to provide the funds for long-term care after site burial operations end. However, there is no guarantee that the licensee would have adequate funds and using this method, there is no opportunity to generate further funds since the disposal site would be filled to capacity and would have no incoming revenues.

A slightly more stringent timing alternative for determining cash flows for closure and for long-term care would be for the licensee to provide funding for closure and for long-term care during site burial operations. Under such a "pay as you go" scenario, the licensee would turn over revenues generated from the surcharge as they are received. However, such a funding arrangement would offer no protection in the case of premature site closure by the licensee.

The method providing the greatest degree of assurance that adequate funds are available for care of a disposal facility would require the licensee to provide financial assurances for closure and for long-term care up front, before the site burial operations begin. This method would offer the strongest possibility that funds are available for closure and for long-term care, since the full amount of funds would always be available throughout the lifetime of the site. However, this option is not viable for the Barnwell site, since financial arrangements for the site have been in existence for some time.

Since the state has already implemented financial assurances for both closure and for long-term care of the Barnwell site, and these mechanisms appear to be generating the proper amount of funds at this time, the staff thinks that the present financial assurance methods are adequate at this time for the Barnwell site. Specifically, the staff finds that the lease arrangement and the trust fund developed by the state of South Carolina are adequate financial assurance mechanisms.

Discussions related to how the state's financial assurance requirements effect the licensee, the state of South Carolina, the waste generator, and the general public may be found in Section 4.3.6.

2.4.3 Potential radionuclide release mechanisms

Radionuclides may migrate from the Barnwell site in a variety of pathways from various release mechanisms that may initiate such transport. Only those release mechanisms that the staff found to be potentially applicable to the Barnwell facility are discussed below. Much of the discussion that follows has been drawn from NUREG/CR-0570.[12]

2.4.3.1 Geomorphological release mechanisms

Potential geomorphological release mechanisms for the transport radionuclides at the Barnwell site are by wind erosion, subsidence, frost heaving, and mass wasting (soil creep).

The release of radionuclides may occur as a result of wind erosion by direct removal of overburden soil. The primary factors pertaining to the rate of wind erosion at the site include climate, topography, vegetative cover, and human activities. Because of the humid climate, general topography of the area, and the vegetative cover on and adjacent to the site, the staff feels that, in both the short- and long-term, the release of radionuclides through this mechanism would be insignificant. Measures to prevent and mitigate the possibility of soil being transported offsite by accidental spills or ruptures are discussed in Sects. 4.1.2 and 4.3.2.

The release of radionuclides may occur indirectly as a result of subsidence through the alteration of surface features that might enhance the possibility of surface erosion or infiltration of meteoric water. The staff believes that subsidence (if it occurs) at the Barnwell site is most likely to occur as a result of burial practices. Current waste burial methods are discussed in Sect. 2.3.3, and both the short- and long-term stabilization methods to ensure trench integrity are discussed in Sects. 2.3.8 and 2.4.4.

Frost heaving is another mechanism that might alter the soil profile at the surface and enhance the possibility of subsequent surface erosion or infiltration of meteoric water. However, based on the relatively mild climatic conditions (see Sect. 3.1) and the vegetative cover at the site, the staff finds the importance of this release mechanism to be insignificant.

Mass wasting is a general term defined as "the dislodgement and downslope transport of soil and rock material under direct application of gravitational body stresses."[19] It includes slow displacements such as creep and rapid movements such as earthflows, rockslides, and avalanches. Mass wasting is primarily controlled by the surface topography, and the staff considers the likelihood of radionuclide release through the mechanism of soil creep at the Barnwell site to be extremely remote.

2.4.3.2 Hydrological release mechanisms

Surface water

Surface water entering a shallow land burial trench may release radionuclides by percolating through the bottom of the trench to groundwater below or by eventually overflowing the trench and contaminating surface areas.[12] The pathway followed will be determined by the permeability of the pit bottom and the rate of water inflow.

The action of surface water may allow water to enter the trench by eroding overlying material. Materials released to the surface by other mechanisms (e.g., biological or human activity, spillage) may be picked up by surface water and leached into the soil or washed down gradient.

Groundwater

The primary radionuclide release mechanism for the Barnwell site concerns groundwater transport. Groundwater may come in contact with buried radioactive waste by groundwater intrusion, percolation of meteoric water and/or snow melt, and overflow.[12] Variables affecting the rate of this potential release mechanism include climate, topography, vegetative cover, soil and sediment properties, waste characteristics, and hydrology.

Percolation of meteoric water and/or snow melt into and through the buried waste by the force of gravity could provide a mechanism for the transport of radionuclides. Chem-Nuclear uses the following methods of attenuating percolation by creating a relatively impermeable trench cap over the buried wastes and by diverting surface water away from the completed trenches (see Sects. 2.3.3 and 4.1).

Overflow relates to the process of producing a saturated condition, caused by percolation, within the burial trench as a result of low permeability sediments forming the trench bottom and side walls. If this condition occurs, the transport of radionuclides could occur as the result of subsurface migration of groundwater or possible surface flow resulting from overflow seepage from the trench. In addition to the measures taken by Chem-Nuclear to prevent percolation, sumps and riser pipes are located in all burial trenches and have the capacity to be monitored (quarterly) for trench fluids and to permit trench dewatering if necessary. More detailed discussion related to this release mechanism may be found in Sect. 4.2.8.

Transport of radionuclides could also occur as the result of groundwater intrusion. The process would occur if the unconfined water table at the site should happen to rise above the level of the trench bottoms (see Sects. 2.4.1 and 3.6.2).

2.4.3.3 Biological release mechanisms

Plant uptake and activities of animals are two basic ways in which radionuclides may be released and transported by biological mechanisms.[12]

The roots of plants growing on the site may infiltrate buried waste and absorb radionuclides which, in turn, may be transported throughout the body of the plant. This mechanism brings radionuclides to the surface, where they may be transported by wind movement of plant debris and ingestion by animals. Growth of plant roots may also cause the physical breakdown of buried waste and disruption of overburden material, which may increase the rates of erosion and water percolation.

Animal transport mechanisms, in addition to the food chain transfer mentioned above, usually result when digging and burrowing animals penetrate the overburden to the level of the buried waste. These types of animals may ingest or otherwise scatter radionuclides. They may also disrupt the surface vegetative cover and the overburden, which may increase erosion and moisture percolation.

2.4.3.4 Human-activity release mechanisms

Two major types of human activity that could disturb buried waste at a decommissioned disposal site are excavation (including digging, drilling, grading, and blasting) and agriculture.[12]

Excavation may release significant quantities of radionuclides. It can occur in situations in which the existence of the buried waste is not known or where information concerning the location is inaccurate. The quantity of radionuclides released depends upon the depth of excavation, waste characteristics, and the amount of time the waste has been buried.

Agricultural activities may cause radionuclide migration or release during cultivation when contaminated soil is brought to the surface and dispersed by erosion. Agricultural plants may take up radionuclides through their root systems and, in this way, introduce them into the food chains of man and other animals. Radionuclides can also be returned to the ground surface in crop residues. Further, irrigation and surface tillage may increase radionuclide migration by increasing the percolation of moisture through the substrate.

2.4.4 Alternative methods of minimizing the potential for radionuclide release and transport over the long term

Geomorphological

The primary geomorphological release mechanisms for the transport of radionuclides at the Barnwell site are wind erosion and subsidence. An alternative method of controlling wind erosion would involve the use of wind breaks (vegetative or physical). As discussed previously, the release of radionuclides through the mechanism is considered insignificant, and the construction or the establishment of wind breaks would most probably not be economically viable. Subsidence at the Barnwell site is most likely to occur as a result of burial practices, waste packaging, and compaction. Alternative methods of unloading and depositing wastes in trenches are currently being investigated by Chem-Nuclear. However, the results and their effectiveness can only be evaluated with the passage of time.

Surface water

The most effective methods for minimizing release by surface water hydrological mechanisms are those that prevent water from entering the trenches. Overlying material may be protected from erosion by planting appropriate forms of vegetation or by covering compacted overburden with other materials (e.g., rocks, gravel, asphalt or concrete).[12] Impervious or low-permeability materials may be used on the soil surface or at subsurface levels over the trench to prevent surface water infiltration. Surface water drainage may be directed away from the trenches by the use of contoured surface areas and/or culverts and ditches.

Water that enters the trenches may be prevented from leaching radionuclides into groundwater by installing low permeability liners. The injection of certain materials (e.g., cement, clay, asphaltic, and polymeric or other chemical materials) into the wastes may reduce the flow of water through the matrix or bind the radionuclides. If water accumulates in trenches equipped with sumps and standpipes, the liquid may be pumped out and treated to remove radionuclides before release. Additional information on these and other methods of minimizing radionuclide release are described in a recent NRC document.[12]

Groundwater

The primary potential radionuclide release mechanism identified at the Barnwell site is by groundwater via percolation, intrusion, and overflow. Alternative methods for minimizing this release mechanism at the Barnwell site would include:

1. increasing the distance between the groundwater table and the bottom of the trench,

2. increase the thickness of the clay caps,

3. substituting the clay caps with a hard layer (concrete, asphalt, etc.) or an impermeable (plastic) membrane, and

4. use various combinations of a subsurface clay, hard layer material, and an impermeable membrane.

Biological and human

The following discussion summarizes methods for minimizing radionuclide release and transport that may occur as a result of biological and human release mechanisms (Sects. 2.4.3.3 and 2.4.3.4). More detailed information concerning these and other methods is given in a recent NRC document.[12]

Plant uptake of radionuclides may be controlled by modifying soils and sediments, introducing barriers between plant roots and buried waste, and appropriate vegetation management practices, including selecting plants with shallow, fibrous root systems, replanting areas disturbed by erosion or human activities, and methods to control the invasion of undesirable species. The effects of digging and burrowing animals may be minimized partially by the elimination of such species, use of overburden materials that inhibit burrowing, or deeper burial of waste.

The most effective method of minimizing biological release mechanisms is site/waste stabilization combined with long-term care, including continued monitoring, maintenance, and surveillance activities at the site. The goal of site stabilization should be to control erosion and stabilize the land surface. The stabilization and long-term care activities should be continued until the radioactivity has decayed to innocuous levels. The time required will depend on the volume and activity of the buried waste and will probably amount to hundreds of years.[12] Following this period of time, the site could be released for unrestricted use.

Several methods may be used to reduce the potential for radionuclide movement resulting from excavation. These include controlled use of the site, use of permanent trench-location markers, and fencing the site to provide exclusive access. Additional measures, such as modifying the substrate with a subsurface hard or rock layer to increase the difficulty of excavation, may also be useful.

Control of radionuclide migration caused by agricultural activities is probably best accomplished by a combination of administrative and physical techniques. Administrative techniques could include banning agricultural activities on the site or limiting the activities to those with the lowest potential for disrupting buried waste. Physical controls might include increasing the burial depth, placing barriers in the soil to exclude plant roots and to limit water percolation, and modifying the ground surface to limit or to eliminate the potential for agriculture.

As with the biological release mechanisms, a site/waste stabilization and long-term care program including physical and administrative controls should be effective in minimizing or eliminating human-activity release mechanisms.

2.5 STAFF OPINIONS AND RECOMMENDATIONS RELATED TO ALTERNATIVES INCLUDING THE CURRENT METHOD OF OPERATION, AND SITE CLOSURE AND STABILIZATION PLANS

This section summarizes staff opinions and recommendations concerning alternatives to and the current method of operation at the Barnwell facility. The staff has found that the Barnwell facility is operated at the forefront of technology related to the shallow land burial of LLW in the Eastern United States. The staff recommendations are intended to be constructive and, if implemented, will improve the overall effectiveness of the Barnwell facility.

2.5.1 The alternative of no action

Staff opinions and recommendations related to this alternative may be found in Sect. 2.6.

2.5.2 Current operational procedures and alternatives relating to waste packaging requirements and alternatives

After reviewing applicable regulations and guidelines related to standards for waste packages of LLW, the staff concludes that they provide adequate protection of public health and safety during transport and disposal. Another assessment[3] has concluded that shipments of LLW will have no significant impact on man or biota.

Current transportation methods and alternatives

The staff has found that transportation by land vehicle is the most viable and economic transportation alternative. Transportation by railroad is probably not a viable alternative on a routine basis and transportation by water is not a practical alternative when considering the Barnwell facility. Shipment of LLW by air may be a viable alternative but is not normally cost effective.

Current waste burial methods and alternatives

The staff found that out of all of the alternative waste burial methods for LLW considered, only two seemed applicable to the Barnwell facility: improved shallow land burial, and engineered structures. Because experience related to the disposal of LLW in engineered structures is very limited, the staff does not recommend this alternative for the Barnwell site. Furthermore, most of the improvements considered in shallow land burial of LLW presented previously are already being implemented by Chem-Nuclear at the Barnwell facility. The staff has no further recommendations concerning current burial methods of LLW at the Barnwell facility.

Waste inventory records and alternatives

The current waste inventory system being used by both Chem-Nuclear and the DHEC is efficient. The staff, therefore, determined that further discussion of alternatives is not warranted.

Monitoring procedures and alternatives

The staff has determined that the implementation of the new improved monitoring system makes the consideration of alternative monitoring procedures unnecessary.

Current measures to minimize public radiation exposure and alternatives

The staff has reviewed Chem-Nuclear's compliance history, operational procedures, and monitoring data and has determined that they demonstrate adequate protection of the public. Consequently, no recommendations for alternative measures have been made.

Current measures to minimize occupational exposure and alternatives

The staff has reviewed Chem-Nuclear's operational procedures and occupational exposure records and has determined that they demonstrate adequate protection of workers. Consequently, no recommendations for alternative measures have been made.

Current site stabilization techniques and alternatives

The staff inspected the site on February 12, 1981, and found the stabilization techniques currently being used by Chem-Nuclear at the Barnwell facility to be effective. Consequently, no alternative stabilization techniques have been recommended by the staff.

2.5.3 Site closure and stabilization

In reviewing the "Preliminary Site Stabilization and Closure Plan for the Barnwell Low-Level Radioactive Waste Disposal Facility" the staff offers the following recommendations:

1. The maximum volume and costs estimated for final disposal of site structures should be updated at specified intervals. These figures may be expected to change with time.

2. Direct gamma-radiation surveys should be conducted at specified time intervals, the procedures and methodologies should be well documented, and the results should be forwarded to the DHEC.

3. The State of South Carolina should give Chem-Nuclear some preliminary conceptual plans of what it intends to do with the site so that the license conditions can be satisfied.

4. Chem-Nuclear should construct hydrographs for each well indicating all previous historical water-level changes. In addition potentiometric maps should be compiled on a quarterly basis to account for seasonal variations in the water table level. This would help both Chem-Nuclear and the DHEC gain a better understanding of changing water table conditions beneath the site resulting from seasonal variations and aid in assuring that proper decisions concerning future site operations continue to be made.

5. The term "statistical increase" should be defined by Chem-Nuclear and the DHEC. Currently, what constitutes a "statistical increase" is purely subjective and arbitrary. Any "statistical increase" should be able to be identified by two or more independent parties assessing the same data and should be reproducible with respect to time.

6. Measures to be implemented by Chem-Nuclear in the event that any evidence of unusual or unexpected rates or levels of radionuclide migration in groundwater is detected should be documented so that the license condition can be satisfied.

7. Condition 15 should be evaluated periodically against the results of monitoring.

2.5.4 Financial guarantees for compliance and alternatives

Funding methods for both the final site stabilization, closure, and decommissioning plan and the post-long-term maintenance and environmental monitoring programs for the Barnwell site are already in place. Alternative funding methods were considered by the staff and were considered to be less effective than those already in place.

2.5.5 Potential radionuclide release mechanisms and alternative methods of minimizing the potential for radionuclide release and transport over the long term

Only those release mechanisms that the staff found to be potentially applicable to the Barnwell facility were considered. The staff also considered alternative methods for minimizing the potential for radionuclide release and transport over the long term and found that Chem-Nuclear has already implemented (except as noted above) those methods that are most applicable to the Barnwell site.

2.6 STAFF CONCLUSIONS REGARDING THE CONTINUING OPERATION OF THE BARNWELL FACILITY

As stated in Sect. 1 the staff was limited to an evaluation of the environmental impacts associated with the following actions:

1. closing the site and implementing site closure and stabilization plans,

2. continuing operations under current conditions, or

3. continuing operations under altered conditions.

The staff concludes that immediate closure of the site and implementation of site closure and stabilization plans cannot be justified from this evaluation. Possible environmental impacts related to air quality, land use, surface water and groundwater, mineral resources, soil, and terrestrial and aquatic biota were examined (see Sect. 4.2) and found to be insignificant.

The staff believes that there is an increasing need of LLW disposal sites. If the burial of LLW is discontinued at this site, another disposal site would need to be established, thus creating the potential for environmental impacts significantly greater than those currently occurring at the Barnwell facility. Additionally, the staff believes that immediate site closure would provide no appreciable environmental advantage and would not be in the public interest.

The staff has found that the Barnwell facility is operated at the forefront of technology related to the shallow land burial of LLW. The staff recommends that present operations continue with due consideration given to the recommendations herein presented by the staff. The staff believes that the implementation of these recommendations will aid in improving the over all effectiveness of the facility in both the short and long term.

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5. P. J. Macbeth, et al., *Screening of Alternative Methods for the Disposal of Low-Level Radioactive Wastes,* NUREG/CR-0308,Washington, D.C., October 1978.

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3. THE AFFECTED ENVIRONMENT

3.1 REGIONAL AND LOCAL CLIMATE

The Barnwell Low-Level Waste Disposal facility (BLLWDF) is located in the Atlantic Coastal Plains province. This area, although subject to continental influences, is protected by the Blue Ridge Mountains to the north and northwest from the more vigorous winters prevailing in the Tennessee Valley. The terrain does not moderate the summer heat. The surrounding areas are characterized by gently rolling hills with no unusual topographic features (except the Savannah River several miles west of the site) that would significantly influence the general climatology.

The description of the meteorology of the BLLWDF site is based on data collected at the Savannah River Plant (SRP) site and at the nearby Bush Airport, Augusta, Georgia.

Wind data are measured at seven 62-m (200 ft) meteorological towers on the SRP site and at the 335-m (1100 ft) WJBF television tower located offsite. Temperature data are also measured at the television tower and at one onsite station that records maximum and minimum temperature, daily rainfall, and continuous measurements of temperature, relative humidity, and pressure. Rainfall is also monitored at seven additional locations at SRP.

The summers are long and humid with many thunderstorms. The summer season has the heaviest rainfall of the year, contributing about 30% of the annual total. Hail at a given location occurs about once every two years.

The fall season has many cool mornings and warm afternoons. About 18% of the annual rainfall is recorded during the fall.

Winters are mild, and, although the cold weather usually lasts from late November to late March, less than one-third of the days have a minimum temperature below freezing. Snowfall is not unusual but does not last long (more than three days of sustained snow coverage is very rare). The winter rainfall represents 25% of the annual total.

Spring is the most changeable season of the year. Infrequent tornadoes occur most often in the spring. An occasional hailstorm may occur in the spring or early summer. Spring rainfall represents 27% of the annual total.[1]

The climate at the BLLWDF site is typical of the region because the topography of the site is similar to that of the area.

3.1.1 Temperature and humidity

The temperature data for the BLLWDF area cover a period of 16 years. Temperature averages and extremes are given in Table 3.1.

Table 3.1. Average and extreme temperatures at the LLWDF site, 1961 to 1976[a]

Month	Average daily temperature (°C)			Extreme monthly temperature (°C)	
	Maximum	Minimum	Monthly	Maximum	Minimum
January	13	2	8	30	−16
February	15	3	9	27	−10
March	20	7	13	32	−6
April	25	12	18	35	1
May	28	16	22	37	5
June	32	19	26	41	9
July	33	21	27	39	14
August	32	21	27	40	13
September	29	18	24	38	5
October	25	12	19	33	−2
November	19	6	13	32	−8
December	15	4	9	28	−9

[a] Average annual temperature 18°C.

Source: *Environmental Information Document—Defense Waste Processing Facility, Vol. I,* DPST-80-249, E. I. duPont de Nemours and Co., Savannah River Plant and Laboratory, Aiken, S.C. (1980).

The average winter temperature is approximately 9°C, and the average summer temperature is 27°C. The annual average temperature is 18°C, with an average daily temperature variation of about -7°C.

The annual average relative humidity in the area of the site, measured from 1964 to 1978, is 66%, with an average minimum of 43% and an average maximum of 90%.

The growing season lasts about 240 days. The average date of the last frost is March 16, and the average date of the first frost is November 12.

3.1.2 Precipitation

The average annual rainfall at the BLLWDF site is 118 cm (46 in.) for the years 1952 through 1978. On the average, rainfall is greatest in March and least in November (see Table 3.2). Snowfall and freezing rain are infrequent and seldom cover the ground for more than a few days.

Table 3.2. Precipitation at LLWDF site, 1952 to 1978

Month	Average monthly rainfall (cm)		
	Maximum	Minimum	Average
January	25.5	3.2	11.0
February	20.2	2.4	10.6
March	22.0	3.8	12.8
April	20.8	3.2	8.7
May	27.7	3.4	10.3
June	27.7	6.3	11.5
July	26.7	5.0	12.1
August	31.3	2.6	12.0
September	22.1	2.5	10.1
October	15.6	0	6.2
November	16.4	0.5	5.9
December	19.1	1.2	9.1
Average annual rainfall			120.3

Source: *Environmental Information Document—Defense Waste Processing Facility, Vol. I,* DPST-80-249, E. I. duPont de Nemours and Co., Savannah River Plant and Laboratory, Aiken, S.C. (1980).

The elevation of the facility makes flooding of the site by local streams most unlikely.

3.1.3 Severe weather

3.1.3.1 Tornadoes

The BLLWDF is in an area where occasional tornadoes are to be expected. Recent data, 1959 through 1971, show that South Carolina is struck by an average of 10 tornadoes per year.[2] Most of the tornadoes occur from March through June with maximum wind speeds up to 418 km/h (260 mph).

Although no BLLWDF facilities have suffered tornado damage, on two occasion: light damage has occurred at nearby SRP facilities. Several other tornado funnels have been sighted in the area but apparently did not touch ground. Studies covering a period from 1916 through 1975 were used to assess the risk of tornado damage to the BLLWDF and show the probability for striking a large building is about 1×10^{-3} per year, compared to 1×10^{-4} per year for striking a single point.

3.1.3.2 Hurricanes and high winds

Thirty-eight hurricanes caused damage in South Carolina during the 272 years of record (1700-1971), an average of one every seven years. Hurricanes occur predominantly during August and September. Because the BLLWDF site is approximately 160 km (100 miles) inland from the coast, high winds of the hurricanes tend to diminish as the storms move over land. Winds of 120 km/h (75 mph) in the area have been measured only once during the history of the operation of the neighboring SRP.

An occasional winter storm may bring strong and gusty surface winds; wind speeds as high as 116 km/h (72 mph) have been recorded. During the summer the only strong surface winds are associated with thunderstorms during which winds up to 64 km/h (40 mph), with stronger gusts, can be generated.

3.2 AIR POLLUTION POTENTIAL AND AIR QUALITY

3.2.1 Temperature inversions

Temperature inversion data are available from instruments on a television tower approximately 24 km (15 miles) from the center of the SRP site. The 1974 temperature measurements between 3 and 335 meter (10 and 1100 ft) were analyzed by comparing the temperature profiles with the adiabatic lapse rate, i.e., the rate at which the temperature would change with height under adiabatic conditions.[3] About 30% of the time, a temperature inversion (stable conditions) extended to or beyond the 3 to 335-meter (10 to 1100 ft) layer. About 9% of the data showed an inversion developing at the lower levels with an unstable layer above; this represents the transition period between the unstable daytime regime and the onset of the nighttime inversion. Thus, conditions were considered stable for about 39% of the time.

Other data taken at the 36 to 91 m (120 to 300 ft) layer and at the 182 to 335 m (600 to 1100 ft) layer indicated that stable conditions existed 30 to 32% of the time from 1966 through 1968, in good agreement with the analysis based on the 1974 data.

3.2.2 Mixing depths

The depth of the nocturnal mixed layer for the area is measured by an acoustic sounder that has been operated continuously since 1974.[4] The average morning mixing depth is about 400 m (1300 ft) in the winter, spring and summer, decreasing to about 300 m (1000 ft) in the fall. The average afternoon mixing depth is about 1000 m (3300 ft) in the winter, 1700 m (5600 ft) in the spring, 1900 m (6200 ft) in the summer, and 1400 m (4600 ft) in the fall. Based on this data, the average annual mixing depth is 938 m (3100 ft).

3.2.3 Wind and dispersion characteristics

Atmospheric diffusion estimates were obtained from meteorological data for a two-year period from January 1976 through December 1977. Seven meteorological towers are scattered throughout the SRP area at an off-site television tower 15 km (9 miles) from the plant boundary (see Fig. 3.1).[5] Instrumentation measures wind direction and velocity mounted 62 m (200 ft) above the ground to match the height of the major SRP stacks. Tower locations are representative of the general landscape of the area and are located where the prevailing winds do not pass over buildings before reaching the towers.

The wind direction frequency near the BLLWDF is shown in Figure 3.2 as percent of time the wind was blowing from different directions. The data is from 62-m-(200-ft) height measurements at the offsite television tower. For the period for 1976 and 1977 the winds blew mainly from the west and southwest quadrant.

3.2.4 Air quality

The Environmental Protection Agency (EPA) data (ref. 6 as cited in ref. 7) indicate that Barnwell County and the six surrounding South Carolina and Georgia counties (Aiken, Allendale, Bamburg and Orangeburg, S.C. and Burke and Richmond counties, GA) are in air quality attainment areas with respect to all criteria air pollutants. This means that the ambient levels of sulfur dioxide (SO_2), nitrogen oxides (NO_x), total suspended particulates (TSP), carbon monoxide (CO), and photochemical oxidants do not exceed the National Ambient Air Quality Standards (NAAQS). The data base used gives the status of the counties as of April 23, 1979. Nonradiological air quality monitoring has not been conducted by Chem-Nuclear at the Barnwell site.

3.3 TOPOGRAPHY

The Barnwell disposal site is located on the Upper Coastal Plain Physiographic Province. Two distinct physiographic subregions, the Pleistocene Coastal Terraces and the Aiken Plateau, occur in the general area of the site.

The Aiken Plateau was once a relatively smooth, gently sloping area with a regional slope to the southeast. Through geologic time it has been deeply eroded by numerous drainage tributaries. Interstream areas

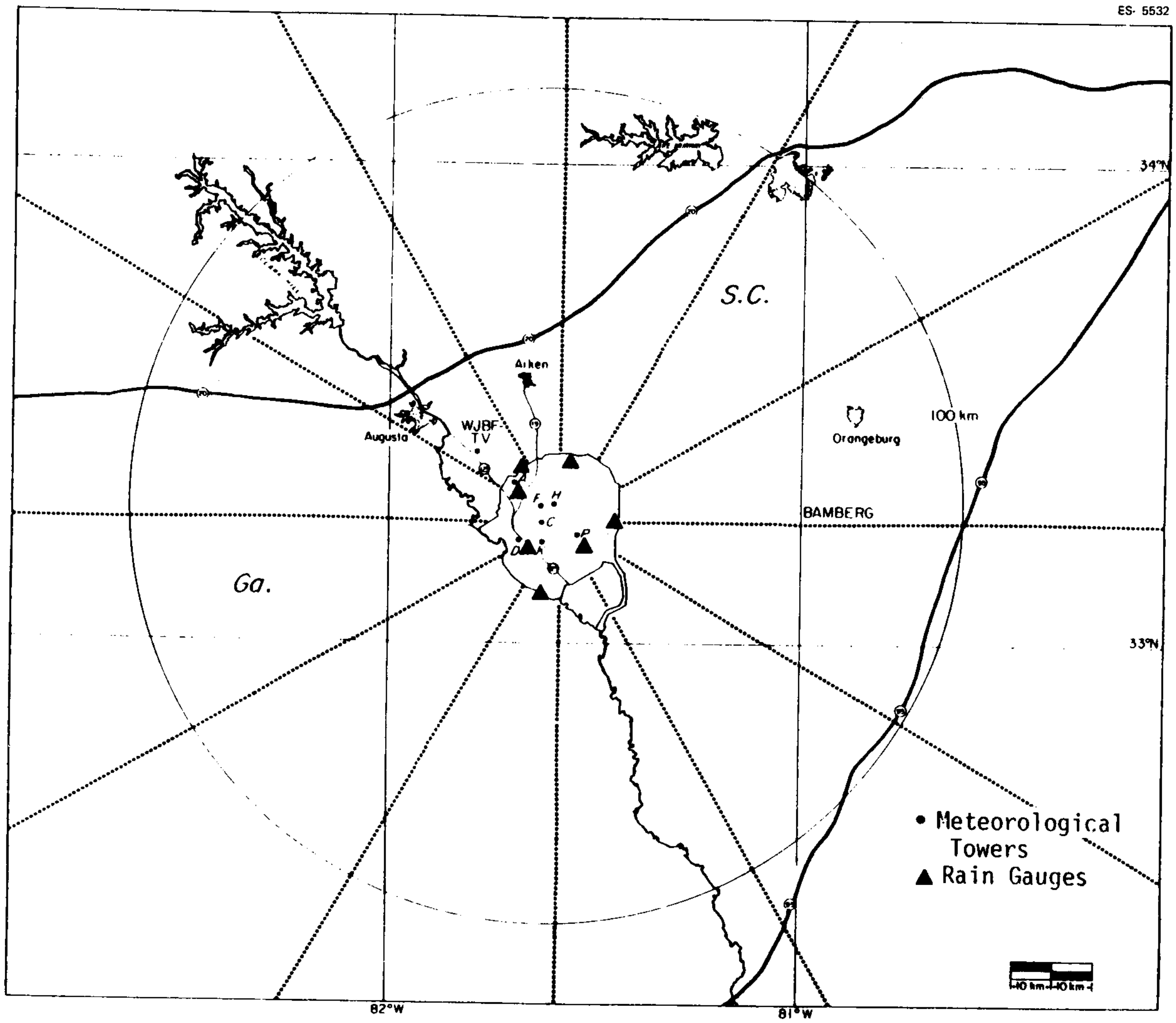

Fig. 3.1. Atmospheric data sources for the nearby SRP. Source: *Environmental Information Document — Defense Waste Processing Facility, Vol. I*, DPST-80-249, E. I. duPont de Nemours and Co., Savannah River Plant and Laboratory, Aiken, S.C. (1980).

underlain exclusively by Cretaceous sediments (Sect. 3.7.1) are characterized by gently rolling hills and few, if any, undrained areas. Interstream areas with a thin cover of Tertiary sediments (Sect. 3.7.1) are characterized by plateaus with steep ravines and numerous undrained "sinks" or "Carolina bays".[8]

The Barnwell site is located near the eastern edge of the Aiken Plateau. Its topography is gently rolling with grade elevation ranging from 73 m (240 ft) to 80 m (260 ft) MSL.[9]

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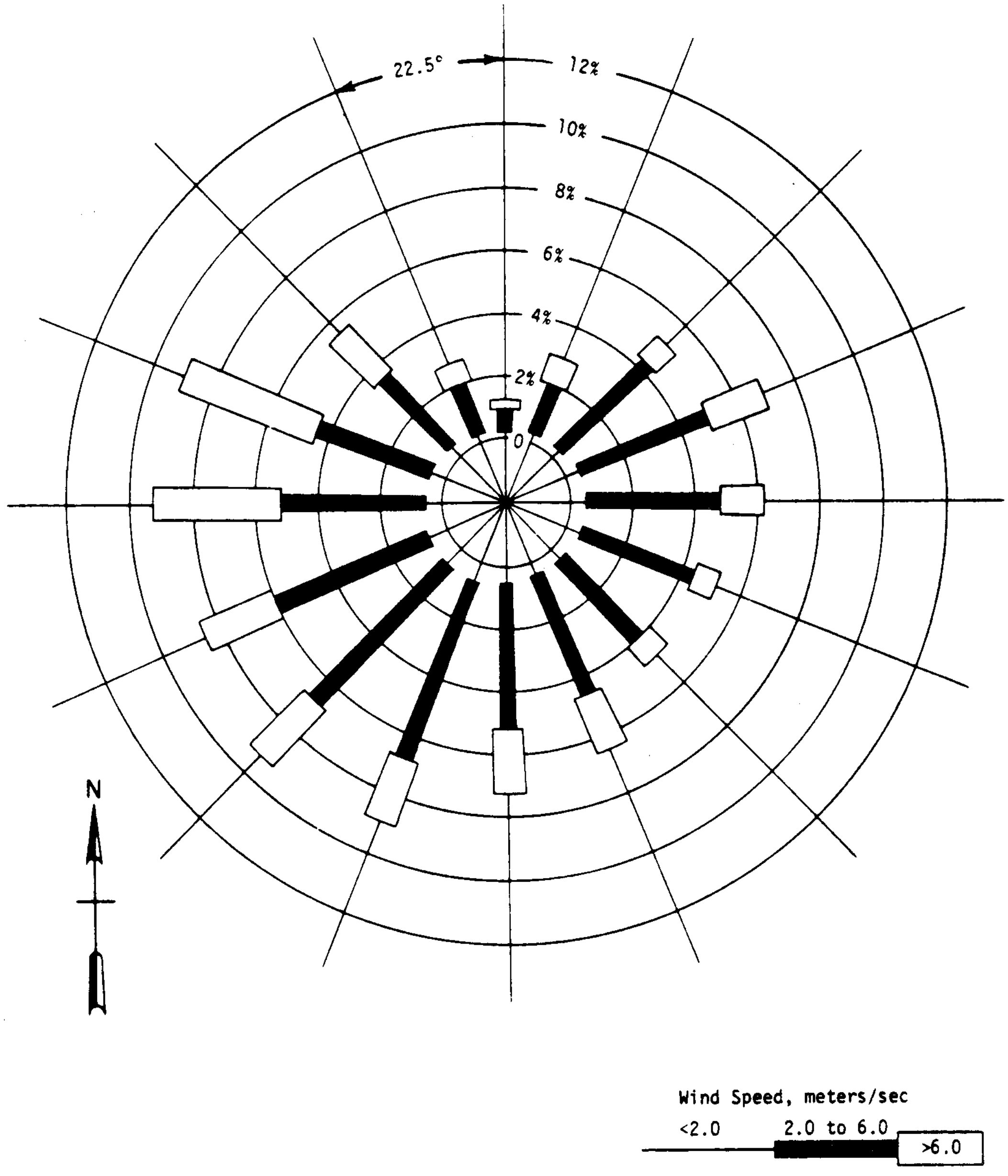

Fig. 3.2. Wind direction frequency near BLLWDF from 1976 to 1977. Source: *Environmental Information Document — Defense Waste Processing Facility, Vol. I,* DPST-80-249, E. I. duPont de Nemours and Co., Savannah River Plant and Laboratory, Aiken, S.C., 1980.

3.4 DEMOGRAPHY AND SOCIOECONOMIC PROFILE

Chem-Nuclear's low-level radioactive waste disposal facility is located in the central portion of Barnwell County, South Carolina, approximately, in highway kilometers (miles), 8 km (5 miles) west of Barnwell, the county seat for Barnwell County, about 68 km (42 miles) southeast of Augusta, Georgia, and approximately 61 km (38 miles) south southeast of Aiken, the county seat of Aiken County (see Figs. 3.3 and 3.4). The site is bounded on the east and north by county road 585 and farmland, on the south by county road 53 and state highway 64 [about 0.8 km (0.5 miles) distant], and on the west by the Allied General Nuclear Services (AGNS) Barnwell Fuel Reprocessing Facility and the Savannah River Plant [approximately 0.3 km (0.2 miles) distant].

After combining and analyzing socioeconomic information gathered from (1) a literature survey; (2) a review of the environmental assessment submitted by Chem-Nuclear; (3) communications with Chem-Nuclear personnel; and (4) communications with state and local planners, employment agencies, and labor market analysts, two major factors affecting the socioeconomic impacts of the disposal facility were disclosed:

1. The labor recruiting area for the facility includes Barnwell, Aiken, Bamberg, and Allendale counties. Workers typically commute from Bamberg and Allendale counties to Barnwell County.[10] Aiken is included in the Augusta, Georgia, Standard Metropolitan Statistical Area (SMSA);* therefore, a large segment of its work force commutes to Augusta (and also to the Savannah River Plant).[10] However, some members of the Aiken labor force commute to Barnwell to work at the disposal facility and at some of the other industries in Barnwell County.

2. Although the recruiting zone for the disposal facility is fairly large, it is erroneous to assume that the workers who have immigrated from outside the commuting region to work for Chem-Nuclear have chosen, given adequate availability of housing and urban-related amenities such as retail districts and recreational and entertainment facilities, to locate in areas excessively distant from the disposal site. Therefore, based on the sizes and infrastructures of the communities near the project, it appears that most of the imported workers have settled in the Barnwell area, with a very small percentage settling in Aiken County (see Sect. 4.3.1 and Appendix C).

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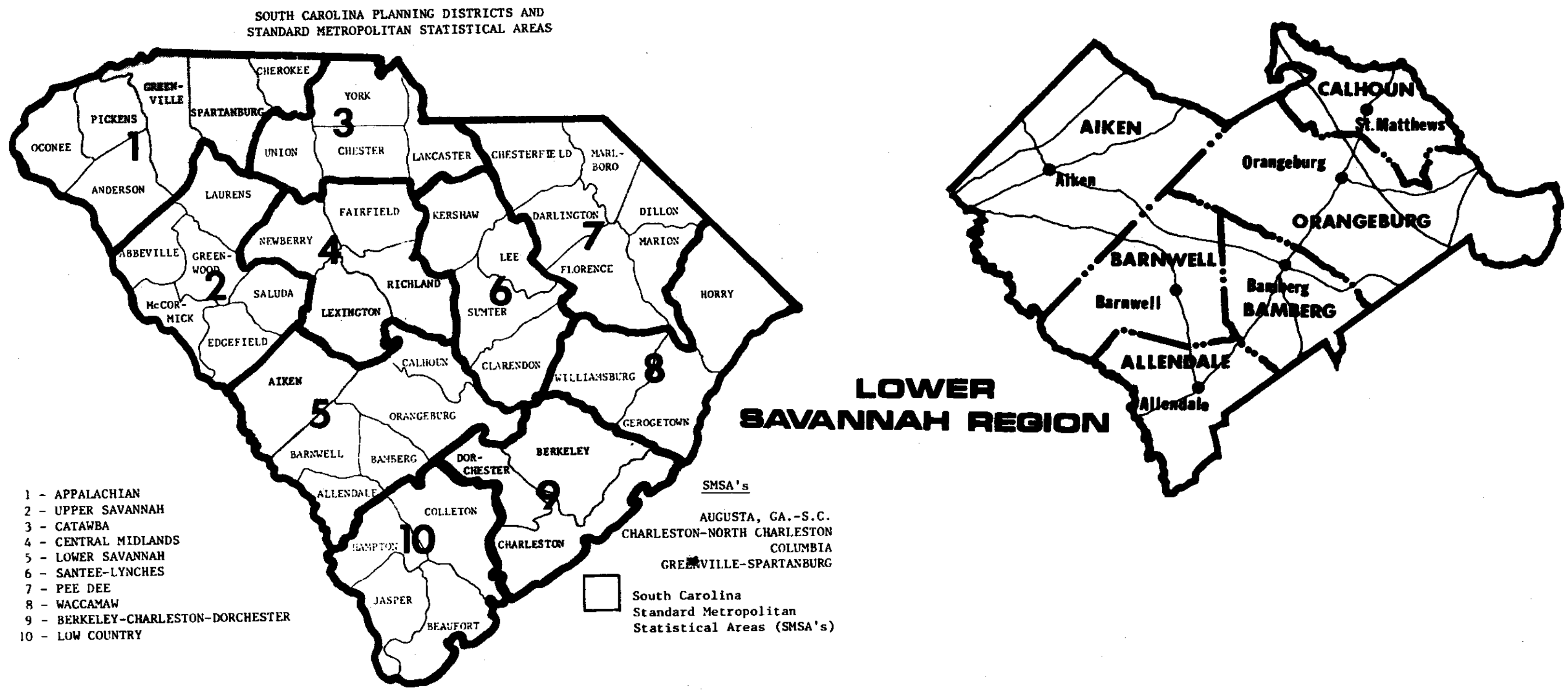
*An SMSA is an integrated economic and social unit having a fairly large population nucleus. Specifically, an SMSA must contain one city of 50,000 or more inhabitants or "twin cities" that have a combined population of at least 50,000. The SMSA includes the county of such a central city, or cities, and adjacent counties that are found to be metropolitan in character and economically and socially integrated with the central city.



*--General location of the Chem-Nuclear facility

Fig. 3.3. The general location of the Chem-Nuclear Facility in context with the state of South Carolina and the Lower Savannah planning district (includes Barnwell, Aiken, Allendale, Bamberg, Orangeburg, and Calhoun counties). Source: Lower Savannah Council of Governments, *Lower Savannah Region Overall Economic Development Plan, 1981-1985*, Aiken, S.C., October 1980; and South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstract: 1980*, Columbia, S.C.

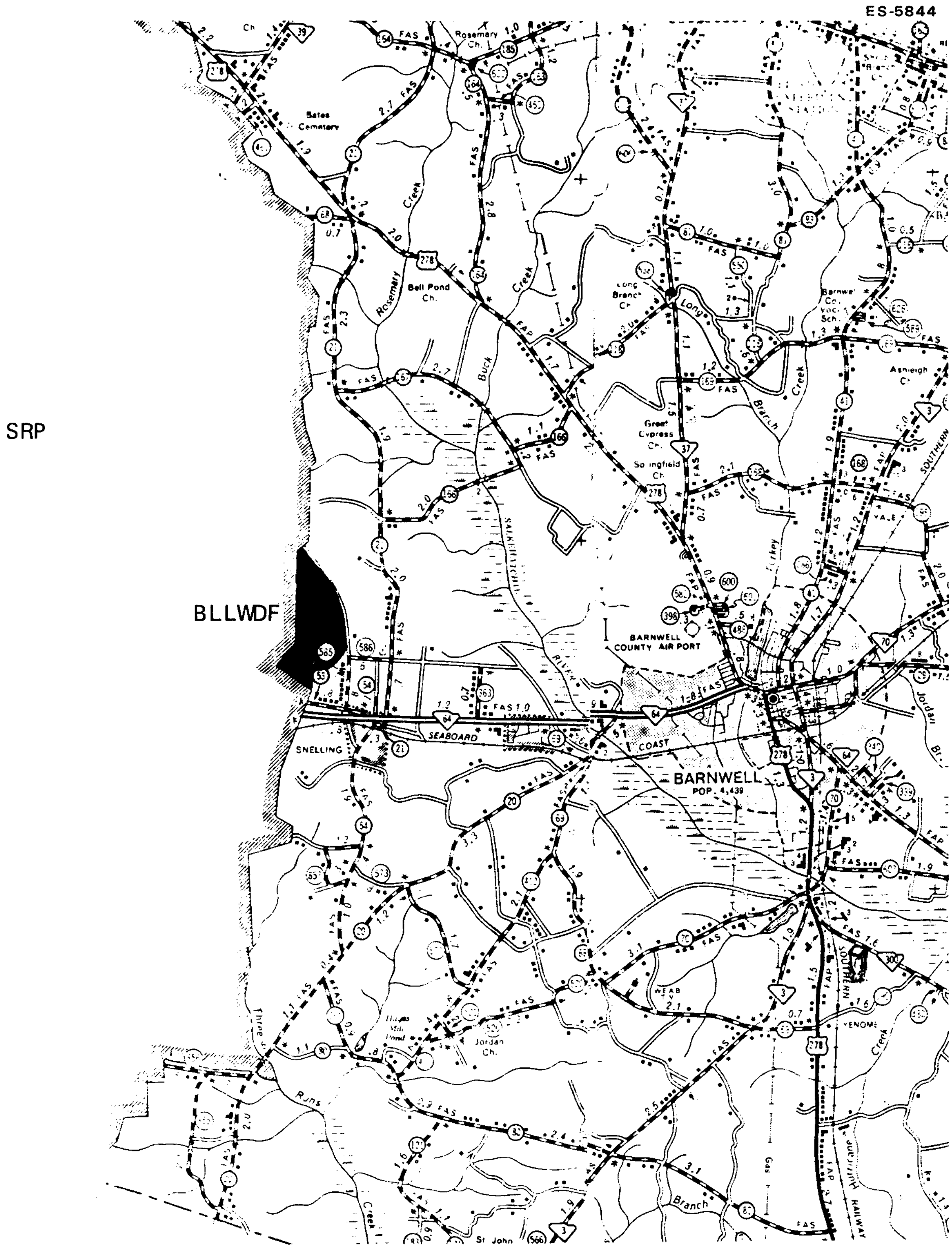


Fig. 3.4. General location of Chem-Nuclear Systems, Inc.

Based on the observations, the socioeconomic descriptions and impact analyses have focused, in two regions: (1) the four-county work force recruiting area and/or (2) the communities and counties affected by in-migrating workers.

3.4.1 Population

Population statistics for the four-county recruiting region are summarized in Tables 3.3 to 3.6. The statistics reveal the following characteristics and trends:

1. The population of the four-county area has steadily increased since 1960, with an overall growth rate of 22.1% from 1960 to 1980 (see Table 3.3); however, this growth has been both temporally and cross-sectionally uneven. Most of the population growth occurred from 1970 to 1980. Each county's population increased and the aggregate growth rate was 15.2% (see Tables 3.3, 3.5, and 3.6). Three of the four counties (Barnwell, Allendale, and Bamberg) lost population from 1960 to 1970 (Allendale's population declined by almost 15.0%: all four counties, as well as the State of South Carolina, experienced net population out-migration in the 1960's (see Table 3.4). Although Allendale and Bamberg counties continued this out-migration trend in the 1970's, Barnwell and Aiken, as well as the entire region, experienced net in-migration.

2. Although the region has become more urbanized over the last 20 to 30 years[10] (see Table 3.3), most (greater than 50%) of the counties' residents continue to live in census-classified rural areas. In 1970 (the 1980 breakdown is not yet available), Aiken County was the most urban of the four counties (44.9%); Allendale was the least urban (37.4%; see Table 3.3). In 1980, Aiken was the most densely populated of the four counties [248.6 persons/km^2 (96.0 persons/sq. mile)]; Allendale County was the most sparsely populated [65.8/km^2 (25.4/sq. mile)].*

3. Each of the four counties is dominated by one or two cities (see Tables 3.5 and 3.6). The major city in Barnwell County is Barnwell, which had a 1980 population of 5572 (28% of the county's population). Barnwell's population grew by almost 26% during the 1970's. Bamberg and Denmark are the major urban areas in Bamberg County, having

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*By comparison, in 1980 the population density for South Carolina was 269.1 persons/km^2 (103.9 per sq. mile). The population densities, as of 1977, for the U.S., District of Columbia, New Jersey, California, and Alaska were 158.5 (61.2), 29,298 (11,312), 2524.0 (974.5), 362.6 (140), and 1.8 (0.7) per km^2 (per sq. mile), respectively.[11]

Table 3.3. Historical population statistics for South Carolina and for Barnwell, Aiken, Allendale, and Bamberg counties

Geographical area	April 1, 1960			April 1, 1970			April 1, 1980[a,b]		Population change (%)	
	Total population	Percent urban	Population density per km^2 (sq. mile)	Total population	Percent urban	Population density per km^2 (sq. mile)	Total population	Population density per km^2 (sq. mile)	1960–1970	1970–1980
South Carolina	2,382,594	41.2	203.8 (78.7)	2,590,713	41.7	222.0 (85.7)	3,119,208	269.1 (103.9)	8.7	20.4
Barnwell	17,659	38.7	82.9 (32.0)	17,176	41.0	80.5 (31.1)	19,868	92.7 (35.8)	−2.7	15.7
Aiken	81,038	36.6	193.0 (74.5)	91,023	44.9	216.8 (83.7)	105,625	248.6 (96.0)	12.3	16.0
Allendale	11,362	27.4	70.4 (27.2)	9,783	37.4	60.1(23.2)	10,700	65.8 (25.4)	−14.7	9.4
Bamberg	16,274	38.7	106.7 (41.2)	15,950	43.7	113.2 (40.4)	18,113	116.8 (45.1)	−2.0	13.6
Regional totals	126,333	36.3		133,932	43.7		154,306		+6.0	+15.2

[a] Final census estimates.

[b] Urban/rural breakdown for 1980 not available.

Source for April 1, 1960 data: South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstract: 1980*, Columbia, S.C.; Source for April 1, 1970 and April 1, 1980 data: U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population and Housing, South Carolina Final Population and Housing Unit Counts*, PHC80-V-42, March 1981.

Table 3.4. Analysis of population changes that occurred in South Carolina and in Barnwell, Aiken, Allendale, and Bamberg counties during the 1960 and 1970 to 1978 time periods

	1960–1970					1970–1978				
			Components of change					Components of change		
	Population change		Births minus deaths	Net migration[a]		Population change		Births minus deaths	Net migration[a]	
	No.	%		No.	%	No.	%		No.	%
South Carolina	207,922	8.7	357,336	−149,414	−6.3	311,000	12.0	211,000	99,000	3.8
Barnwell	−483	−2.7	2,627	−3,110	−17.6	2,200	12.6	1,600	600	3.4
Aiken	9,985	12.3	11,481	−1,496	−1.8	7,700	8.5	6,600	1,100	1.2
Allendale	−1,670	−14.7	1,491	−3,161	−27.8	400	4.1	700	−300	−3.0
Bamberg	−324	−2.0	2,185	−2,509	−15.4	500	3.4	1,100	−500	−3.3

[a]Total net migration was calculated by subtracting the natural population change (births minus deaths) from the total population change. The percent estimate was calculated by dividing the net migration estimate by the 1960 or 1970 population estimate.

Source: South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstract: 1980*, Columbia, S.C.

Table 3.5. Population statistics for the cities, towns, and census divisions in Barnwell and Aiken counties

County, city, town, or census division	1980 population[a]	1980 population distribution (% of county population)	1970 population	1970 population distribution (% of county population)	Population change 1970 to 1980	
					Total	%
Barnwell County	19,868	100.0	17,176	100.0	2,692	15.7
Barnwell division	8,340	42.0	6,962	40.5	1,378	19.8
Barnwell city	5,572	28.0	4,439	25.8	1,133	25.5
Hilda town	355	1.8	331	1.9	24	7.3
Blackville division	4,279	21.5	3,915	22.8	364	9.3
Blackville town	2,840	14.3	2,395	13.9	445	18.6
Kline-Snelling division	2,053	10.3	*b*			
Kline town	315	1.6	305	1.8	10	3.3
Snelling town	111	0.6	150	0.9	−39	−26.0
Williston division	5,196	26.2	*b*			
Elko town	329	1.7	202	1.2	127	62.9
Williston town	3,173	16.0	2,594	15.1	579	22.3
Aiken County	105,625	100.0	91,023	100.0	14,602	16.0
Aiken division	38,195	36.2	*b*			
Aiken city	14,978	14.2	13,436	14.8	1,542	11.5
Beech Island division	4,839	4.6	3,884	4.3	955	24.6
Edisto-Shaws division	2,994	2.8	2,186	2.4	808	37.0
Jackson division	2,650	2.5	2,929	3.2	−279	−9.5
Jackson town	1,771	1.7	1,928	2.1	−157	−8.1
Monetta division	3,138	3.0	2,460	2.7	678	27.6
Monetta town	84	0.1	147	0.2	−63	−42.9
New Ellenton division	5,940	5.6	5,276	5.8	664	12.6
New Ellenton town	2,628	2.5	2,546	2.8	82	3.2
North Augusta division	40,041	37.9	*b*			
Burnettown town	359	0.3	434	0.5	−75	−17.3
North Augusta city	13,593	12.9	12,883	14.2	710	5.5
Salley division	2,562	2.4	2,149	2.4	413	19.2
Perry town	273	0.3	209	0.2	64	30.6
Salley town	584	0.6	450	0.5	134	29.8
Wagener division	3,355	3.2	2,942	3.2	413	14.0
Wagener town	903	0.9	723	0.8	180	24.9
Windsor division	1,911	1.8	1,485	1.6	426	28.7
Windsor town	55	0.1	*b*			

[a] Final counts.
[b] Data not available.

Source: U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population and Housing, South Carolina Final Population and Housing Unit Counts*, PHC80-V-42, March 1981.

Table 3.6. Population statistics for the cities, towns, and census divisions in Allendale and Bamberg counties

County, city, town, or census division	1980 population[a]	1980 population distribution (% of county population)	1970 population	1970 population distribution (% of county population)	Population change 1970 to 1980	
					Total	%
Allendale County	10,700	100.0	9,783	100.0	917	9.4
Allendale division	5,789	54.1				
Allendale town	4,400	41.1	3,620	37.0	780	21.5
Fairfax division	2,913	27.2	2,806	28.7	107	3.8
Fairfax town	2,061	19.3	1,937	19.8	124	6.4
Millett division	686	6.4	552	5.6	134	24.2
Sycamore division	1,312	12.3				
Sycamore town	261	2.4	229	2.3	32	14.0
Ulmer town	91	0.9	109	1.1	−18	−16.5
Bamberg County	18,118	100.0	15,950	100.0	2,168	13.6
Bamberg division	7,119	39.3	6,244	39.1	875	14.0
Bamberg town	3,672	20.3	3,406	21.4	266	7.8
Denmark division	7,399	40.8	6,205	38.9	1,194	19.2
Denmark city	4,434	24.5	3,571	22.4	863	24.2
Ehrhardt division	1,872	10.3	1,754	11.0	118	6.7
Ehrhardt town	353	1.9	478	3.0	−125	−26.2
Olar division	1,728	9.5	1,747	11.0	−19	−1.1
Govan town	109	0.6	136	0.9	−27	−19.9
Olar town	381	2.1	423	2.7	−42	−9.9

[a]Final census estimate.
[b]No data available.

Source: U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population and Housing, South Carolina Final Population and Housing Unit Counts,* PHC80-V-42, March 1981.

1980 populations of 3672 and 4434, respectively; together, these municipalities accounted for almost 45% of the county's population. Aiken, North Augusta, Allendale, and Fairfax are the major cities in Aiken and Allendale counties, having 1980 populations of 14,978, 13,593, 4400, and 2061, respectively.

3.4.2 Housing

3.4.2.1 Regional overview

Housing statistics for the four-county region are presented in Tables 3.7, 3.8, and 3.9. The statistics reveal the following important characteristics and trends:

1. In the past, a fairly large percentage of the housing in Barnwell, Allendale, and Bamberg counties has consisted of overcrowded substandard units (deteriorating and dilapidated dwellings) that lack one or more plumbing facilities. The condition of housing in Allendale County was the worst (see Table 3.7); in 1970, 38% of the housing was substandard, nearly 46% lacked one or more plumbing facilities, and about 29% were overcrowded (1.01 or more persons per room).

Table 3.7. Historical housing statistics for Barnwell, Aiken, Allendale, and Bamberg counties

County	1970 housing statistics			
	Total units	Substandard units[a] (%)	Lacking one or more plumbing facilities (%)	Overcrowded units[b] (%)
Barnwell	5,384	30.2	30.2	31.9
Aiken	29,400	14.1	14.1	10.8
Allendale	3,043	38.2	45.8	28.5
Bamberg	4,852	31.6	31.9	29.5
Regional totals	42,679	19.8	20.4	16.8

[a]Substandard units consist of detiorating plus dilapidated dwellings.

[b]Overcrowded units are those with 1.01 persons per room.

Sources: Lower Savannah Council of Governments, *Initial Housing Element Update, Lower Savannah Region,* Aiken, South Carolina, April 1978; and U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population and Housing, South Carolina Final Population and Housing Unit Counts,* PHC80-V-42, March 1981.

2. From 1970 to 1980, about 14,750 housing units were added to the four-county housing stock (see Tables 3.8 and 3.9). Most of these units (10,391, 70.4% of the regional total) were built in Aiken County. Barnwell County's housing stock increased by 1898 units during the 1970's; 581 additional units were constructed in the city of Barnwell. According to ref. 10, residential development in the region has taken three forms: (1) urban fringe development around the larger incorporated areas such as Barnwell and Aiken, (2) the formation of small unincorporated communities, and (3) housing intermittently located along major and secondary roads. The latter form (3) has been the most common type of residential development.

According to a housing study conducted by the Lower Savannah Council of Governments in 1978,[12] an overwhelming majority of the housing units in the Lower Savannah region* were single family units (∿89%); only a small percentage were mobile homes (6%), duplex (3%), or multifamily (2%) structures.

3.4.2.2 Barnwell area

As of February 1981, an average of 50 to 70 houses were for sale within the area encompassing the city of Barnwell. The selling prices for

*The Lower Savannah Region includes Orangeburg and Calhoun counties, as well as Barnwell, Aiken, Allendale, and Bamberg counties.

Table 3.8. Housing counts for the cities, towns, and census divisions in Barnwell and Aiken counties

County, city, town, or census division	1980 housing count[a]	1980 housing count distribution (% of county total)	1970 housing count	1970 housing count distribution (% of county total)	Housing change 1970 to 1980	
					Total	%
Barnwell County	7,282	100.0	5,384	100.0	1,898	35.3
Barnwell division	3,080	42.3	2,260	42.0	820	36.3
Barnwell city	2,047	28.1	1,466	27.2	581	39.6
Hilda town	141	1.9	114	2.1	27	23.7
Blackville division	1,466	20.1	1,118	20.8	348	31.1
Blackville town	991	13.6	722	13.4	269	37.3
Kline-Snelling division	764	10.5	*b*			
Kline town	124	1.7	90	1.7	34	37.8
Snelling town	41	0.6	53	1.0	–8	–22.6
Williston division	1,972	27.1	*b*			
Elko town	105	1.4	68	1.3	37	54.4
Williston town	1,212	16.6	878	16.3	334	38.0
Aiken County	39,791	100.0	29,400	100.0	10,391	35.3
Aiken division	14,519	36.5	*b*			
Aiken city	6,173	15.5	4,759	16.2	1,414	29.7
Beech Island division	1,753	4.4	1,163	4.0	590	50.7
Edisto-Shaws division	1,085	2.7	666	2.3	419	62.9
Jackson division	962	2.4	938	3.2	24	2.6
Jackson town	667	1.7	591	2.0	76	12.9
Monetta division	1,150	2.9	730	2.5	420	57.5
Monetta town	32	0.1				
New Ellenton division	2,160	5.4	1,630	5.5	530	32.5
New Ellenton town	972	2.4	768	2.6	204	26.6
North Augusta division	15,137	38.0	*b*			
Burnettown town	167	0.4	179	0.6	–12	–6.7
North Augusta city	5,470	13.7	4,342	14.8	1,128	26.0
Salley division	1,015	2.6	717	2.4	298	41.6
Perry town	100	0.3	63	0.2	37	58.7
Salley town	252	0.6	208	0.7	44	21.2
Wagener division	1,308	3.3	998	3.4	310	31.1
Wagener town	362	0.9	293	1.0	69	23.5
Windsor division	702	1.8	456	1.6	246	53.9
Windsor town	34	0.1	*b*			

[a] Final counts.

[b] No data available.

Source: U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population and Housing, South Carolina Final Population and Housing Unit Counts,* PHC80-V-42, March 1981.

these homes varied from \$10,000 to 130,000; the price for a 60 m^2 (1800 ft^2), three-bedroom, two-bath house was approximately \$60,000 (personal communication, E. C. Spencer, Sales Associate, Century 21 Southern Properties, Inc., February 11, 1981). Because of several factors, (1) the availability of land for development and (2) the availability of Barnwell city water and sewer hookups, local builders can expand the housing stock fairly quickly to satisfy demand increases (personal communication, E. C. Spencer, Sales Associate, Century 21 Southern Properties, Inc., February 11, 1981). Currently, seven housing subdivisions exist in the Barnwell area in various stages of development in which unit prices starting at about \$40,000.[13]

Table 3.9. Housing counts for the cities, towns, and census divisions in Allendale and Bamberg counties

County, city, town, or census division	1980 housing count[a]	1980 housing count distribution (% of county total)	1970 housing count	1970 housing count distribution (% of county total)	Housing change 1970 to 1980	
					Total	%
Allendale County	3973	100.0	3043	100.0	930	30.6
Allendale division	2107	53.0	*b*			
Allendale town	1634	41.1	1238	40.7	396	32.0
Fairfax division	1088	27.4	822	27.0	266	32.4
Fairfax town	769	19.4	601	19.8	168	28.0
Millett division	242	6.1	153	5.0	89	58.2
Sycamore division	536	13.5	*b*			
Sycamore town	105	2.6	77	2.5	28	36.4
Ulmer town	40	0.1	40	1.3	0	0.0
Bamberg County	6384	100.0	4852	100.0	1532	31.6
Bamberg division	2480	38.8	2004	41.3	476	23.8
Bamberg town	1315	20.6	1162	23.9	153	13.2
Denmark division	2460	38.5	1772	36.5	688	38.8
Denmark city	1684	26.4	1166	24.0	518	44.4
Ehrhardt division	732	11.5	558	11.5	174	31.2
Ehrhardt town	171	2.7	168	3.5	3	1.8
Olar division	712	11.2	518	10.7	194	37.5
Govan town	36	0.6	32	0.7	4	12.5
Olar town	173	2.7	153	3.2	20	13.1

[a] Final census estimate.
[b] No available data.

Source: U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population and Housing, South Carolina Final Population and Housing Unit Counts,* PHC80-V-42, March 1981.

Rental properties are not as readily available as owner-occupied, single-family housing units. As of August 1980, there were 195 one- to four-bedroom apartments in three apartment complexes for which a waiting list is usually in effect.[13] Sixty-seven subsidized rental units have recently been added to the Barnwell housing stock.[13]

3.4.3 Employment

Over the past few years, the unemployment rates for the four-county labor market area have, with few exceptions, been higher than those recorded for the nation and for the state (see Table 3.10). The highest unemployment rates have consistently occurred in Barnwell and Allendale counties, averaging, respectively, 10 and 12.7% in 1980. In December 1980, Allendale's rate was 11.7% and Barnwell's was 9.8, ranking the counties third and tenth highest among the 46 counties in South Carolina. Aiken and Bamberg counties' unemployment rates are usually 2 to 4% less than the rates reported by Barnwell and Allendale counties. The relative stability of Aiken County's employment is primarily a result of the county's dependence on the Savannah River Plant. The area economies will undoubtedly continue to be adversely affected by a slowed national economy (via decreased spending and increased unemployment) during 1981. Construction and manufacturing may be the first and most severely affected

Table 3.10. Labor force and unemployment estimates for selected years for South Carolina and for Barnwell, Aiken, Allendale, and Bamberg counties, including national unemployment estimates

Year	National unemployment rate[a] (%)	South Carolina		Barnwell County		Aiken County		Allendale County		Bamberg County	
		Civilian labor force[b]	Unemployment rate[a] (%)	Civilian labor force[b]	Unemployment rate[a] (%)	Civilian labor force[b]	Unemployment rate[a] (%)	Civilian labor force[b]	Unemployment rate[a] (%)	Civilian labor force[b]	Unemployment rate[a] (%)
1974	5.6	1,146,000	5.9	10,320	6.0	38,710	6.0	3,430	10.5	6,190	6.5
1975	8.5	1,177,000	8.8	9,340	11.3	39,790	7.7	3,570	14.3	6,260	8.9
1977	7.0	1,275,000	7.2	8,980	10.7	44,340	7.9	3,590	9.5	7,120	8.3
1979	5.8	1,306,000	5.0	9,460	6.2	40,630	5.3	3,720	7.0	6,970	5.3
1980	7.1	1,307,200	6.8	9,360	10.0	40,970	7.1	3,550	12.7	6,570	8.7
Change, % (1974–1980)		+14.1		–9.3		+5.8		+3.5		+6.1	

[a]Unemployment rates are not seasonally adjusted. Also, workers involved in labor management disputes were included.

[b]The labor force data were projected from the 1979 current population survey benchmark and were adjusted for commuting and dual job holding. Consequently, these data represents persons by place of residence and are not strictly comparable to the establishment based nonfarm wage and salary industry employments series.

Source: South Carolina Employment Security Commission, Research and Analysis Section, *Monthly Labor Estimates, January 1974–December 1980,* Columbia, South Carolina, January 1981; and *South Carolina Annual Planning Information for 1981,* May 1980.

industries. If the recessionary slump is prolonged, trade and service industries would also be affected. In keeping with trends elsewhere, the jobless ranks will be swelled by minorities, females, and those under 25 years of age.

County employment statistics for nonagricultural job categories are presented in Table 3.11. As shown, manufacturing is by far the most important sector, accounting for 51.1% of the four-county region's nonagricultural employment in 1979. Other important nonagricultural sectors are government, trade, and services. As indicated in Table 3.11, construction employment in Barnwell County declined dramatically from 1974 to 1979; most of the decrease occurred in 1974 and 1975 upon construction cessation of Allied General's nuclear fuel reprocessing facility.

3.4.4 Economics

3.4.4.1 Regional economic base

The "basic" industries of a region are those that involve either the exportation of goods and services to points outside the defined region or the marketing of goods and services to buyers who come from outside the region's boundaries.* Because manufacturing and agriculture are, by far, the most important industries in the four-county region, this section focuses on these two basic economic activities.

Manufacturing

As noted in Sect. 3.4.3, manufacturing is the dominant nonagricultural activity. The most important manufacturing industries are lumber and wood products or are textile- or nuclear-related. The textile industry (textile mills, apparel plants, and other textile-related facilities) accounted for approximately 37% of the region's manufacturing employment in 1979.[14] The textile industry is especially important in Aiken County, comprising 23% of total nonagricultural employment in 1979 and 44% of manufacturing employment.[14] According to ref. 10, p. 27:

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*The definition of an appropriate region is very important in economic base analyses. For this study, the four-county region surrounding the site — Barnwell, Aiken, Allendale, and Bamberg counties — was chosen as the basic region. This is a judgmental decision of the staff and is based on the belief that the vast majority of the socioeconomic impacts related to the Chem-Nuclear facility have and will continue to occur in the defined region.

Table 3.11. Nonagricultural wage and salary employment statistics for South Carolina and for Barnwell, Aiken, Allendale, and Bamberg counties: 1974 and 1979

Industry	South Carolina			Barnwell County			Aiken County			Allendale County			Bamberg County		
	Employment level[a] 1979 (thousands)	Employment distribution 1979 (%)	Employment increase 1974–1979 (%)	Employment level[a] 1979	Employment distribution 1979 (%)	Employment increase 1974–1979 (%)	Employment level[a] 1979	Employment distribution 1979 (%)	Employment increase 1974–1979 (%)	Employment level[a] 1979	Employment distribution 1979 (%)	Employment increase 1974–1979 (%)	Employment level[a] 1979	Employment distribution 1979 (%)	Employment increase 1974–1979 (%)
Total nonagricultural wage and salary[b]	1,177.8	100.0	16.0	7,270	100.0	−8.8	37,120	100.0	16.6	2,990	100.0	16.8	4,820	100.0	15.9
Manufacturing	399.3	33.9	6.2	3,990	54.9	5.6	19,520	52.6	11.4	1,200	40.1	14.3	1,970	40.9	16.6
Construction	72.8	6.2	−3.2	370	5.1	−80.0	1,600	4.3	11.1	260	8.7	271.4	110	2.3	−26.7
Transportation and Public utilities	53.3	4.5	25.1	290	4.0	190.0	1,250	3.4	3.3	90	3.0	12.5	180	3.7	−10.0
Wholesale and retail trade	223.0	18.9	25.6	680	9.4	−9.3	5,050	13.6	18.5	500	16.7	−2.0	790	16.4	14.5
Finance, insurance and Real estate	46.6	4.0	20.1	190	2.6	46.2	1,010	2.7	29.5	60	2.0	50.0	80	1.7	0.0
Services & mining[c]	154.5	13.1	25.8	480	6.6	11.6	4,000	10.8	49.8	170	5.7	−5.6	750	15.6	78.6
Government	228.4	19.4	25.4	1,270	17.5	36.6	4,680	12.6	18.1	720	24.1	14.3	960	19.9	3.2

[a]Employment is by establishment or place-of-work basis; 1979 figures are preliminary.

[b]Totals may not add due to rounding.

[c]Included in services are those services related to ageiculture, as well as the wide range of services to individuals and business establishments. Also included are forestry and fisheries for years previous to 1977.

Source: South Employment Security Commission, Research and Analysis Section, *South Carolina's Manpower in Industry*, Columbia, South Carolina, August 1980.

The greatest economic variable in the region continues to be the nuclear energy industry. This industry, employing nearly 10,000 people (many skilled in high technology), is at the crossroads of its future development potential. The Department of Energy's Savannah River Plant (a significant employer in the region) is seeking a firm commitment to proceed with solidification of liquid nuclear wastes. Moreover, the idled Barnwell Nuclear Fuel Plant is anticipating future policy changes with respect to spent fuel reprocessing. Finally, the Chem-Nuclear Plant is ... (impacted by) policy changes in the area of low-level nuclear waste management. The region's economy will (therefore) ... be impacted enormously by the outcome of ... (nuclear-related) policy decisions.

Agriculture

Historically, agriculture has been a major component of the region's economy. Although fewer persons are agriculturally employed,* the number of farms is decreasing (the average size is increasing), and the acreage devoted to agriculture has declined over the past 20 years, the agricultural sector is still very strong in the region.[15] The cash receipts from farm marketings have increased over the years (see Table 3.12) as has the average per farm value of products sold.[15] In 1979, the major crops and livestock products were soy beans, cotton, peaches (Aiken County), hogs, and cattle.[16]

Table 3.12. Cash receipts from farm marketings for Barnwell, Aiken, Allendale, and Bamberg counties 1978 and 1979, in 10^3 dollars

County	1978 Cash receipts[a,b]					1979 Cash receipts[b,c]				
	Total receipts	Crops[d]	State rank[e] (crops)	Livestock[f]	State rank[e] (livestock)	Total receipts	Crops[d]	State rank[e] (crops)	Livestock[f]	State rank[e] (livestock)
Barnwell	14,128	9,514	19	4,614	30	17,381	12,760	19	4,621	31
Aiken	22,775	8,959	20	13,816	9	25,123	11,692	22	13,431	9
Allendale	15,373	10,769	18	4,604	31	17,955	14,296	17	3,659	35
Bamberg	16,646	8,696	22	7,950	14	20,415	12,373	21	8,042	16
Regional totals	68,922	37,938		30,984		80,874	51,121		29,753	

[a] Revised estimates.
[b] Receipts estimates exclude government payments.
[c] Preliminary estimates.
[d] The crops category includes potatoes, sweet potatoes, forest products, nursery and greenhouse products, peanuts, hay crops, seed crops and other miscellaneous field crops, fruits and nuts, excluding peaches.
[e] There are 46 counties in South Carolina.
[f] The livestock category includes farm chickens, other poultry, turkeys and turkey eggs, sheep and lambs, wool, honey, beeswax, horses, and mules.

Source: South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstract: 1980,* Columbia, South Carolina. Original sources: Federal-State Crop and Livestock Reporting Service, USDA and Clemson University, *South Carolina Cash Receipts,* AE 416, September 1980.

*For example, in 1960, there were about 6100 persons working as farmers, farm laborers, managers, and foremen; by 1970, employment had declined to about 2000, a 68% decrease.[15]

3.4.4.2 Income

Comparative statistics indicate that, although increasing through time, the per capita personal income estimates for South Carolina and for the four counties in the Barnwell labor-market area have consistently been lower than national averages (see Table 3.13). For example, South Carolina's average per capita income was estimated to be $6344 in 1978, 61% above the estimate recorded in 1973, and a considerably improved 354% better than 1960's estimate.[11] However, when compared with the nation and other states, South Carolina has traditionally fared poorly; the state ranked 47th in per capita earnings in 1978, 47th in 1970, and 48th in 1960.[11] In turn, Barnwell, Allendale, and Bamberg have traditionally been among the poorer counties in South Carolina. Because of industrial development, Barnwell has moved up in the income rankings over the past 10 to 15 years (see Table 3.13). However, Allendale and Bamberg, being agriculture oriented and having high unemployment rates, are among the poorer counties in the state, ranking, respectively, 44th and 36th (out of 46 counties) in average per capita income in 1978. Aiken County, because of its proximity to Augusta and to the Savannah River Plant (many SRP employees live in Aiken), is one of the richer counties in South Carolina, ranking 5th in 1978.

Table 3.13. Per capita personal income in current dollars for the United States, the southeastern states,[a] and Barnwell, Aiken, Allendale, and Bamberg counties for selected years in the 1970's

Geographical area	1973	1975	1977	1978	Rank in state or nation 1978	Increase 1973–1978 (%)
United States		5861	7043	7854		34.0[b]
Southeastern states[a]		5029	6090	7624		51.6[b]
South Carolina	3945	4665	5676	6344	47	60.8
Barnwell	3535	4381	5086	5844	21	65.3
Aiken	4370	5221	6464	7157	5	63.8
Allendale	2570	3139	3510	4186	44	62.9
Bamberg	3125	3653	4254	4982	36	59.4

[a] Includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Tennessee, Virginia, West Virginia, and South Carolina.

[b] 1975–1978 percentage increase.

Source: South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstract: 1980,* Columbia, S.C.

Earnings estimates for several job categories in the Columbia, South Carolina, job-bank area are summarized in Table 3.14 and should be reasonably indicative of wage scales in the Barnwell labor-market area.

Table 3.14. Earnings statistics for employment openings received from manufacturing and nonmanufacturing firms in the Columbia, South Carolina,[a] job bank area for commonly occurring jobs as of Dec. 31, 1980

Job title	Annual earnings ($)		
	Low	Median	High
Manufacturing sector			
Electronics technician	10,400	11,440	11,980
Clerk, general	7,280	8,320	8,444
Machinist	11,128	11,128	14,560
Production machine tender	7,218	8,320	13,520
Assembler, production	6,448	7,363	8,632
Electrician	11,419	12,792	16,578
Pipe fitter	18,616	19,552	20,488
Nonmanufacturing sector			
Manager, retail store	7,218	9,755	10,941
Secretary	7,000	8,320	12,000
Clerk, general	6,448	7,925	11,190
Salesperson, furniture	6,760	7,925	9,090
Police officer	7,149	8,281	9,413
Farmworker, dairy	6,448	7,800	7,800
Carpenter	6,448	12,480	18,720
Plumber	11,440	11,960	12,480
Tractor trailer truck driver	6,448	10,400	18,720

[a]The Columbia job bank area includes Aiken and Barnwell counties plus seven other counties in central South Carolina.

Source: Research and Analysis Section, South Carolina Employment Security Commission, *South Carolina Wage Rates and Fringe Benefits* Columbia, S.C., December 1980.

The estimates are predictable; the skilled tradespersons–plumbers, electricians, machinists, pipe fitters, and tractor-trailer truck drivers — are relatively well paid, and the wages of unskilled workers are either equal to or slightly above the Federally-mandated minimum wage.

3.4.4.3 Finance and taxes

As of June 30, 1979, 39 commercial banking offices and 10 savings and loan (S&L) associations were located in Barnwell, Aiken, Allendale, and Bamberg counties. Most of these facilities (24 banks and 6 S&Ls) were located in Aiken County; eight (seven banks and one S&L) were in Barnwell County (two banks and the S&L were located in the city of Barnwell).[10,13]

As of June 30, 1979, the assets (time and demand deposits) of the area's banking facilities totalled \$247.8 million; the S&L deposits totalled \$157.1 million.[16] Most of the bank assets (\$228.1 million; 92% of the total assets) were funds deposited by individuals, partnerships, and corporations (see Table 3.15). Most of the S&L assets were held by the S&L's in Aiken County (\$131.5 million; ∿84% of total S&L deposits).

Table 3.15. Amount of deposits by type in commercial banks in Barnwell, Aiken, Allendale, and Bamberg counties, as of June 30, 1979, as 10^3 dollars

County	Number of banking offices	Total deposits[a]	IPC[b] demand deposits	IPC[b] savings and time deposits	Public funds demand deposits	Public funds savings and time deposits
Barnwell	7	35,725	12,256	21,349	726	1,372
Aiken	24	157,485	60,426	84,588	3,256	5,999
Allendale	3	18,069	5,744	9,997	851	1,346
Bamberg	5	36,547	11,822	22,008	550	1,974
Regional totals	39	247,826	90,248	137,942	5,383	10,691

[a] Total deposits include other types of deposits not listed.
[b] Individuals, partnerships, and corporations.

Source: South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstract: 1980,* Columbia, S.C. Original source, *Summary of Deposits in All Commercial and Mutual Savings Banks.*

Allocations from state tax revenues (see Table 3.16) and real and personal property taxes are the major sources of revenue for the affected counties and municipalities (the state of South Carolina does not use the property tax as a source of revenue).[13] Manufacturers', utilities', and all personal properties are uniformly assessed by the South Carolina Tax Commission for each county. The remaining real property not assessed by the Commission is assessed by each county, and all county political subdivisions are required to utilize the county's assessment. The county, municipalities, and other political subdivisions set millage rates.[13] The South Carolina Constitution divides all property into eight classes. Real and personal property owned by or leased to manufacturers or utilities are assessed at 10.5% of fair market value;* with minor exceptions, all other personal property is assessed at the same ratio.[13] Except for residential and agricultural property (and a few

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*According to the Constitution of the state of South Carolina, manufacturers are specifically allowed three property tax exemptions:[13]

1. All inventories not sold or available for sale at retail, including raw materials, are exempt.
2. All new facilities plus expansions costing more than \$50,000 are exempt for five years from all county property taxes except those levied for the purpose of operating public schools or municipalities.
3. Pollution control equipment and facilities are exempt.

Table 3.16. South Carolina fiscal 1979 to 1980 tax allocations to Barnwell, Aiken, Allendale, and Bamberg counties

County	Gasoline tax ($)	Income tax ($)	Bank tax ($)	Beer and wine tax ($)	Alcoholic liquors tax ($)	Insurance tax and brokers premium tax ($)	Homestead tax ($)	Total allocation ($)
Barnwell	126,009	194,477	9,340	16,155	50,911	45,607	37,650	480,149
Aiken	405,621	1,030,669	46,499	85,609	254,951	239,921	180,353	2,243,623
Allendale	83,035	109,735	5,519	9,115	28,727	25,887	23,502	285,520
Bamberg	106,481	180,603	13,944	15,001	47,281	42,172	35,396	440,878
Regional totals	721,146	1,515,484	75,302	125,880	381,870	353,587	276,901	3,450,170

Source: South Carolina Budget and Control Board, Division of Research and Statistical Services, *South Carolina Statistical Abstracts: 1980,* Columbia, S.C.

other minor exceptions), all other real properties are assessed at 6%, legal residencies and qualifying agricultural properties are assessed at 4%.[13] In 1980, the Barnwell County property tax rate was 129 mills, from which schools received 109 mills (personal communication, P. Main, Clerk and Treasurer for the city of Barnwell, 15 June 1981). Residential and commercial properties were taxed, respectively, at four and six percent of assessed value.[13] The 1980 rate for Barnwell city was 65 mills (city property owners must also pay county taxes). Barnwell County is currently undergoing a reassessment program. According to current law, the reassessment program shall not produce more than 1% additional revenue and should result in reduced millage rates.[13]

Effective September 1, 1979, Barnwell County began levying a business license tax on Chem-Nuclear disposal revenues. This county tax affects only commercial low-level radioactive waste disposal operators; Chem-Nuclear's facility is currently the only operation of this type in Barnwell County (personal communication, P. Rinehart, Barnwell County Supervisor's Office, June 18, 1981). Disposal revenues are taxed at a 2.4% rate to a maximum of $240,000 per annum. According to Chem-Nuclear (EA, p. 164), this tax has been passed on to their customers, resulting in a disposal charge increase of $13.77/m^3 ($0.39/ft^3) of waste.

The state of South Carolina derives most of its revenues by levying a wide variety of taxes (see Table 3.16); however, income taxes (corporate and individual) and four percent retail sales and use taxes are the major revenue contributors. Total state revenues for the 1979–1980 fiscal year were $1.598 billion – 1.22 billion (∿76%) came from income and sales taxes [sales taxes accounted for $576 million (36%); $644 million (40%) were income tax collections].[16] Counties and other political subdivisions are not allowed to levy retail sales taxes.[13]

3.4.4.4 Community services and public facilities

Education

Statistics for the Barnwell public school district are summarized in Table 3.17. The school system has spent about $500,000 over the past five years for new facilities and classrooms.[13] In addition to these public facilities, three private kindergartens are located in Barnwell. A private school (grades K through 12), with an enrollment of about 500 students, is located in Blackville approximately 18 km (11 miles) from Barnwell: few Barnwell families send their children to this private school.[13] The University of South Carolina has two branch campuses in the region. One is located in Aiken; the other – the Salkehatchie Regional Campus – is located in the town of Allendale approximately 27 km (17 miles) from Barnwell. There are two technical colleges in the region: one in Bamberg County, the other in Aiken County.[13] The Denmark technical school (Bamberg County) provides technical education for residents in Barnwell, Bamberg, and Allendale counties: free bus service to this facility is available for any student living in the tri-county area. In addition to these technical colleges, several vocational centers serving the various school districts are located in the region.

Table 3.17. Barnwell School District 4500 statistics, as of February 1981[a]

Schools	Grades	Enrollments
Barnwell Elementary School	K–5	1100
Guinyard-Butler Middle School	6–8	520
Barnwell High School	9–12	660
Barnwell County Area Vocation School	10–12	350
Harold Sewell Developmental Center	Ungraded	60

[a]Average number of Barnwell High School graduates attending a college or university = ~50%. Gross expenditure per pupil = ~$1,450. Pupil-teacher ratio = ~18.

Sources: B. McLellan, Administrative Assistant, Barnwell School District 4500, personal communication, February 11, 1980; and Barnwell Area Chamber of Commerce, *Economic Analysis of the Barnwell Area,* August 1980.

Fire and police protection

Barnwell's police force consists of a chief-of-police and ten full-time officers; the department owns five fully equipped patrol cars.[13] The Barnwell County Sheriff's department consists of the sheriff, two deputies, and one clerk.[10] The sheriff's office and the Barnwell, Blackville, and

Williston police departments are connected to one radio communications system.[10] State law enforcement agencies also provide protection for the city of Barnwell and Barnwell County.

Barnwell's fire department, which consists of three pumper trucks, and 2 full-time and 24 volunteer firemen, provides fire protection for Barnwell city and the area around the city.[13] The department has written agreements with Denmark and Bamberg in Bamberg County and verbal agreements with Williston and Hilda in Barnwell County and Allendale in Allendale County.[13] The fire insurance rating for Barnwell is seven on a scale of one (best) to ten (worst).[13] In addition to the Barnwell department, three other fire departments in Barnwell County are recognized by the Insurance Services Office: these are located in Blackville, Hilda, and Williston.[13]

Medical services

As of August 1980, five physicians (representing family practice, internal medicine, and surgery specialties), four dentists, an optometrist, a chiropractor, a hospital, and a nursing home were located in the city of Barnwell.[13] The hospital, the Barnwell County Hospital, is a 61 bed acute care facility that provides both outpatient and inpatient services.[13] The nursing home, the Barnwell County Nursing Home, is a 40-bed skilled care nursing facility.[13] Both the hospital and nursing home are non profit organizations. In addition to the practitioners in Barnwell city there are three family-practice physicians, three dentists, one chiropractor, and one optometrist also practicing in Barnwell County.[13] Also, there are three other general hospitals and three intermediate care facilities located within reasonable commuting distance of the disposal site:[10]

1. Aiken Community Hospital — 190 bed facility (24-h emergency room) serving the Aiken County area.
2. Allendale County Hospital — 40 bed facility located in Fairfax.
3. Bamberg County Memorial Hospital — 50 bed facility.
4. Williston, Barnwell County — one intermediate care facility.
5. Blackville, Barnwell County — two intermediate care facilities.

Water supply systems

Sources of public water supply in the region surrounding the site include both surface water and groundwater. In general, the larger urban communities such as Aiken utilize surface water; most of the smaller towns and rural communities use public (and private) groundwater wells.[15] Groundwater is abundant and relatively shallow in the region's sand aquifers. The Tuscaloosa formation, the major aquifer in the area, supplies water to large industries in the area.[15]

Barnwell's water system is city owned and operated. Water is obtained from 11 deep wells; the system is capable of supplying water at a maximum rate of about 29.9×10^6 L/d (7.9×10^6 gpd); peak usage is approximately 12.9×10^6 L/d (3.4×10^6 gpd); and treated water storage capacity is about 1.6×10^6 L (4.3×10^5 gal) in three elevated storage tanks.[15]

Sewage and solid waste disposal systems

Unlike the public water supply systems, public wastewater disposal service is inadequate in many sections in the region surrounding the disposal site. No public systems exist in many of the smaller towns in the region. Some areas have sewage collection service but no sewage treatment: in most cases, wastewater treatment does not satisfy Federal Water Pollution Control Act requirements.[15]

Less than half of Barnwell County is served by public sewer systems.[15] Barnwell, Blackville, and Williston are the only towns with public sewer systems.[15] Barnwell's treated sewage disposal system has a treatment capacity of approximately 3.8×10^6 L/d (1.0×10^6 gpd); the current flow on the system is about 50% of design flow capacity ($\sim 1.9 \times 10^6$ L/d (5.0×10^6 gpd)].[13] The city plans to change to an activated sludge system and to expand the system to handle 7.6×10^6 L/d (2.0×10^6 gpd).[13]

Barnwell County utilizes sanitary landfill facilities for solid waste disposal. The city of Barnwell provides garbage pick-up services for its residents (personal communication, A. P. Black, Barnwell City Administrator, June 17, 1981).

Utilities

Electricity is distributed throughout the region by the South Carolina Electric and Gas Company and by several rural electric cooperations.[10] These REA cooperatives purchase electricity from the publicly owned Central Electric Power Cooperative of the South Carolina Public Service Authority.[10] Electrical service is provided to any industrial customer. The Urquhart Station on the Savannah River in Aiken County, owned and operated by the South Carolina Electric and Gas Company, is the only general-purpose generating plant in the region.[10] The Savannah River Plant generates electricity to support its operations.[10]

Natural gas is supplied by the South Carolina Electric and Gas Company.[10] Industrial users can be supplied up to 1415 m^3 (5.0×10^5 ft^3) per day of firm (uninterrupted) natural gas with no restrictions on use, up to 4.25×10^4 m^3 (1.5×10^6 ft^3) per day of firm gas used in a process, and up to 2.83×10^4 m^3 (1.0×10^6 ft^3) per day of standard interruptible gas.[10] Fuel oils are available locally from several suppliers or in bulk quantities from terminals at the port of Charleston.[10] Propane is piped into South Carolina by Dixie Pipeline Company, which has a terminal in Lexington, South Carolina, about 80 km (50 miles) from Barnwell.[10]

Southern Bell provides telephone service; the local calling area for Barnwell city includes Allendale, Blackville, Denmark, and Williston.[10]

Transportation

The major movement of traffic through Barnwell County is east-west on U.S. 278, which ties Charleston, South Carolina, with Augusta, Georgia, and is routed through the towns of Blackville, Elko, and Williston (see Fig. 3.4). The second largest movement of traffic through the county is north-south through Blackville and Barnwell on State Highway 3. Another primary artery is U.S. 278, which connects both Barnwell city and County with Aiken County and Augusta, Georgia, in the northwest and with Allendale County and Hilton Head Island, South Carolina, in the southeast.[15] All other highways within the county function as "feeder" or "connector" roads:* State Highway 64, the connector between the disposal site and Barnwell, and State Highway 70 and county road 41 feed into Barnwell and fit within these categories.[15] Southeastern Stages provides bus service for Barnwell city south to Savannah and west to Augusta and Atlanta; Trailways and Greyhound offer daily service for Barnwell County, with primary connections to Savannah and Columbia, South Carolina.[13]

Two railroad companies, Seaboard Coast Line and Southern, have lines passing through Barnwell city and County.[13] Southern has an east-west line paralleling U.S. 78 and also operates a north-south line connecting Columbia and the Georgia coast; the Seaboard line is an east-west line passing through Barnwell and Hilda. All six incorporated communities in the county have rail service.[15] Amtrak passenger service is available to Columbia on a daily basis to points northeast and south, with connections to the west.[13]

Commercial airline service for the region is provided at Augusta's Bush Field by Delta, Piedmont, and Wheeler airlines. Limited air service (private transportation and crop dusting services and hanger facilities) is provided at Barnwell County Airport, approximately 1.6 km (1 mile) north of Barnwell on U.S. 278.[13] This county facility has three 1524 m (5000 ft) paved, lighted runways.[13] Similar facilities are located in Aiken County (Aiken Municipal Airport has two paved runways), Allendale County (located between the cities of Allendale and Fairfax), and Bamberg County (two sod runways).

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*The South Carolina Highway Department has developed a functional classification for highways:[15]

1. Interstates and freeways — major limited-access highways designed to facilitate large traffic volumes.

2. Arterials — major roads that carry heavy flows of traffic and have free access and at-grade intersections.

3. Collectors — local service roads that feed traffic to and from the arterial system.

The Barnwell area is served by numerous motor carriers, most of which have major terminals in Augusta; two specialized carriers have terminals in Barnwell.[13] United Parcel Service also provides daily service.[13]

The transportation system in the region around the site is primarily a land-based system; the nearest and largest seaports are located at Charleston and Savannah.[15]

Recreation

The most significant recreational and open-space areas in the region are locally operated public facilities and semi-public/private facilities; Federal and state parks are available but represent a smaller fraction of the region's facilities (see Table 3.18 for an inventory of the region's outdoor facilities).[10]

The city of Barnwell maintains two parks, employs a full-time recreation director, and has organized recreation programs which utilize local school facilities.[10,13] Included in the privately operated facilities in Barnwell County (most of which are not accessible to the public) are three county clubs.[10] Hunting and fishing are popular recreational activities. A fairly large lake (Lake Edgar Brown) is located within the Barnwell city limits.[13]

3.5 LAND USE

3.5.1 Land resources

The data shown in Table 3.19 illustrate the basic pattern of land use in Barnwell County, S.C. The majority of the land surface in the county is occupied by Federal facilities (34%), forestland (32%), and cropland (24%). The presence of the SRP accounts for the high percentage occupied by Federal land. Cropland and forestland percentages for Barnwell County are not substantially different from those for the region. The six South Carolina and Georgia counties surrounding Barnwell have 55% of their land area occupied by forestland and 29% by cropland.[7]

The land-use pattern in the immediate vicinity of the site has been described in several reports (refs. 17 and 18 and EA, p. 4). The waste disposal facility is located adjacent to the Barnwell Nuclear Fuel Plant owned by AGNS and near the SRP (Fig. 3.5). When licensed, the AGNS facility will reprocess spent fuel elements from light-water nuclear power reactors. The ultimate operating status of this facility is unclear because of licensing problems. SRP is involved in the production of special nuclear materials and transuranic elements, chemical separations and processing of various reactor products, and other related nuclear research and development activities.[9] Much of the land surrounding the waste disposal site, other than that occupied

Table 3.18. Inventory of recreation facilities in Barnwell, Aiken, Allendale, and Bamberg counties: 1980

Recreational classification	Barnwell County		Aiken County		Allendale County		Bamberg County		Regional Totals	
	Number of facilities	Hectares (acres) utilized	Number of facilities	Hectares (acres) utilized	Number of facilities	Hectares (acres) utilized	Number of facilities	Hectares (acres) utilized	Number of facilities	Hectares (acres) utilized
Mini parks	7	8.1 (20)	33	33.6 (83)	2	0.8 (2)	7	4.5 (11)	49	47.0 (116)
Neighborhood parks	5	13.8 (34)	19	40.5 (100)	29	1.6 (4)	1	0.8 (2)	54	56.7 (140)
Playfields	4	19.4 (48)	13	64.3 (159)	17	1.2 (3)	4	6.5 (16)	38	91.4 (226)
Recreation complexes	0	0	3	62.3 (154)	0	0	1	1.2 (3)	4	63.5 (157)
Citywide parks	0	0	1	5.7 (14)	0	0	0	0 0	1	5.7 (14)
District parks	1	141.6 (350)	3	1843 (4553)	0	0	1	121.4 (300)	5	1964 (4853)
Totals	17	182.9 (452)	72	2049.4 (5063)	58	3.6 (9)	14	134.4 (332)	151	2228 (5506)

Source: Lower Savannah Council of Governments, *Lower Savannah Region Overall Economic Development Plan, 1981–1985*, Aiken, South Carolina, October 1980. Original source: Lower Savannah Council of Governments, *Regional Outdoor Recreation Plan, 1980.*

Table 3.19. Land use in Barnwell County, South Carolina

Land-use category	Area (ha)	Category as percentage of total land area
Federal land	49,755	34
Urban land	3,212	2
Small lakes[a]	226	1
Pastureland	6,114	4
Cropland	34,797	24
Forestland	46,179	32
Other land[b]	9,508	6
Total	143,195	100

[a] Includes lakes smaller than 16 ha and rivers.

[b] Includes houses, swamps, etc.

Source: R. J. Olson, C. J. Emerson and M. K. Nungessor, *Geoecology: A County-Level Environmental Data Base for the Conterminous United States,* ORNL/TM-7351, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1980.

by SRP and the AGNS facility, is predominantly rural with the major land use activities being timber and crop production. The primary farm products are soybeans, corn, and cotton (EA, p. 4). Other land uses adjacent to the waste disposal site include several tracts managed by International Paper Company for pulp wood logging, land occupied by St. Paul's Church, one area used for farming, and two tracts of land not currently being used.[17]

3.5.2 Historical, archaeological, and scenic values

The National Register of Historic Places lists the following historic sites in the vicinity of the waste disposal site in Allendale and Barnwell counties, South Carolina:[19-21]

Allendale County

Allendale vicinity

- Antioch Christian Church, southwest of Allendale on South Carolina Highway 3.
- Erwinton Plantation, southwest of Allendale off U.S. Highway 301.
- Gravel Hill Plantation, southwest of Allendale off U.S. Highway 301.
- Red Bluff Quarries, 21 km (13 mi) southwest of Allendale off U.S. highway 301.
- Roselawn, 4.8 km (3 mi) southwest of Allendale on South Carolina Highway 47.
- Smyrna Baptist Church, south of Allendale on South Carolina Highway 22.

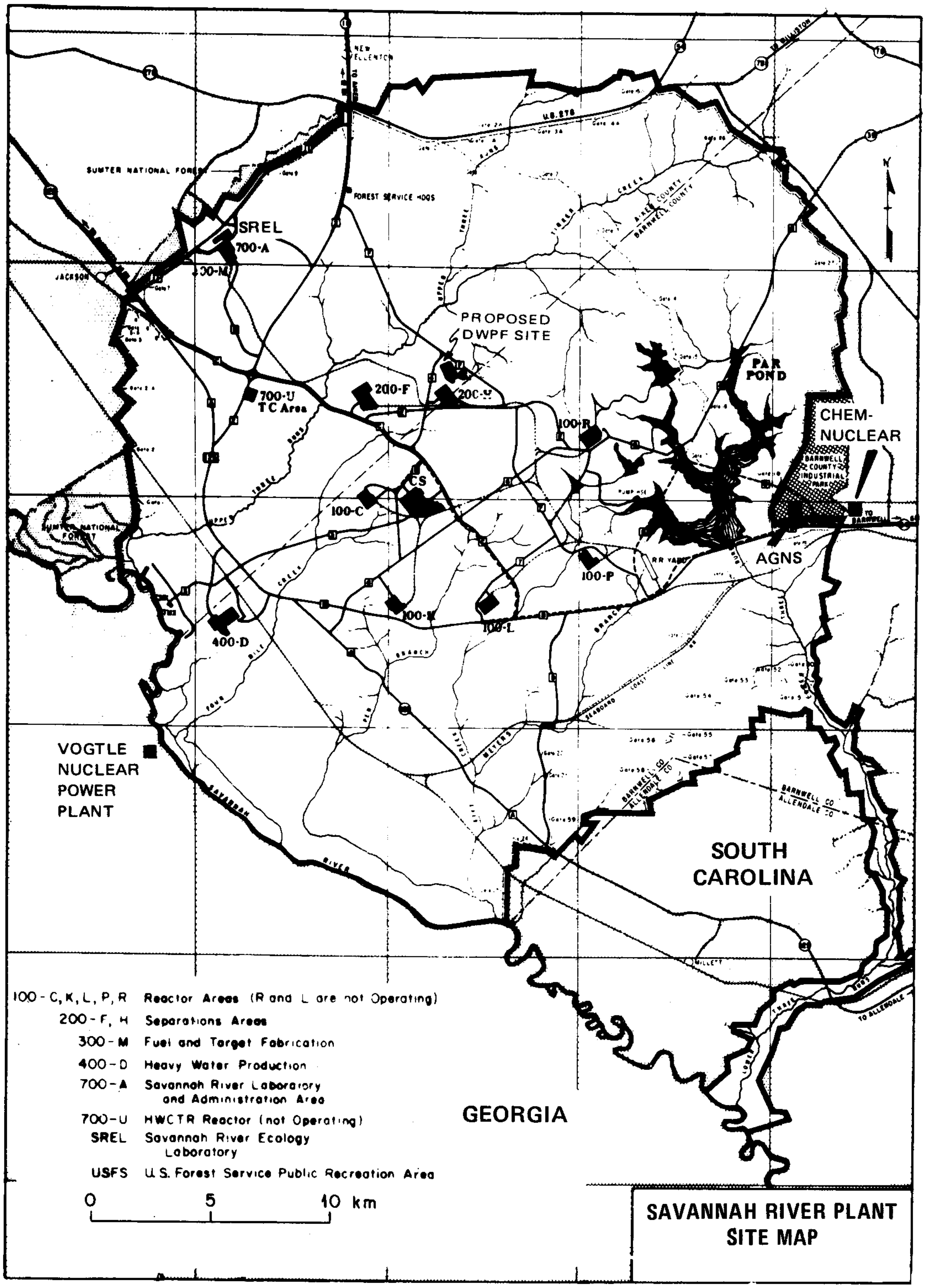

Fig. 3.5. The Chem-Nuclear Barnwell site.

Johnson's Landing Vicinity
- Lawton Mounds, 1.2 km (0.7 mi) south of Johnson's Landing off South Carolina Highway 73.

Peeples vicinity
- Fennell Hill, northwest of Peeples off South Carolina Highway 73.

Barnwell County
Barnwell
- Banksia Hall, 108 Reynolds Road.
- Church of the Holy Apostles (Episcopal), 1706 Hagood Ave.
- Church of Holy Apostles Rectory, 1700 Hagood Ave.
- Bethlehem Baptist Church, Wallace and Gilmore Streets.
- Old Presbyterian Church, 1905 Academy Street.

This list has been verified by Dalton, Brock, and Mallin of the S.C. Department of Archives and History (communication with staff, February 13, 1981). They indicated that there are no additional sites being considered for listing in the National Register. Since the southeastern half of the waste disposal site is within the city limits of Snelling, S.C.,[17] an effort was made to determine if there are important historic resources in the Snelling area. According to Margaret Marion, Historic Preservation Planner, Lower Savannah Council of Governments, one property may be eligible for National Register listing (Margaret Marion, Lower Savannah Council of Governments, March 6, 1981). However, it is not on or adjacent to the waste disposal site.

The National Registry of National Landmarks[22] has no listings for the area of South Carolina near the Barnwell site.

The waste disposal site and vicinity have little archeological value (Margaret Marion, Lower Savannah Council of Governments, March 6, 1981). Archeological studies are being conducted, however, on the Savannah River Plant Reservation (Dr. R. L. Stephenson, State Archeologist, February 13, 1981). Data generated by these studies may be helpful in predicting whether important archeological resources are likely to occur in other areas near the SRP.

The Barnwell State Park, located approximately 22.5 km (14 miles) northeast of the waste disposal site, is the only such facility in the area. The park is utilized primarily for family recreation.[23]

3.6 WATER

3.6.1 Surface Water

Major rivers near the BLLWDF are the Savannah River located about 21.6 km (13.5 mi) to the west and south and the Salkehatchie about 4.1 km (2.5 mi) to the north and east (Fig. 3.6). The facility is located on the edge of the watershed of Lower Three Runs Creek (LTRC), a

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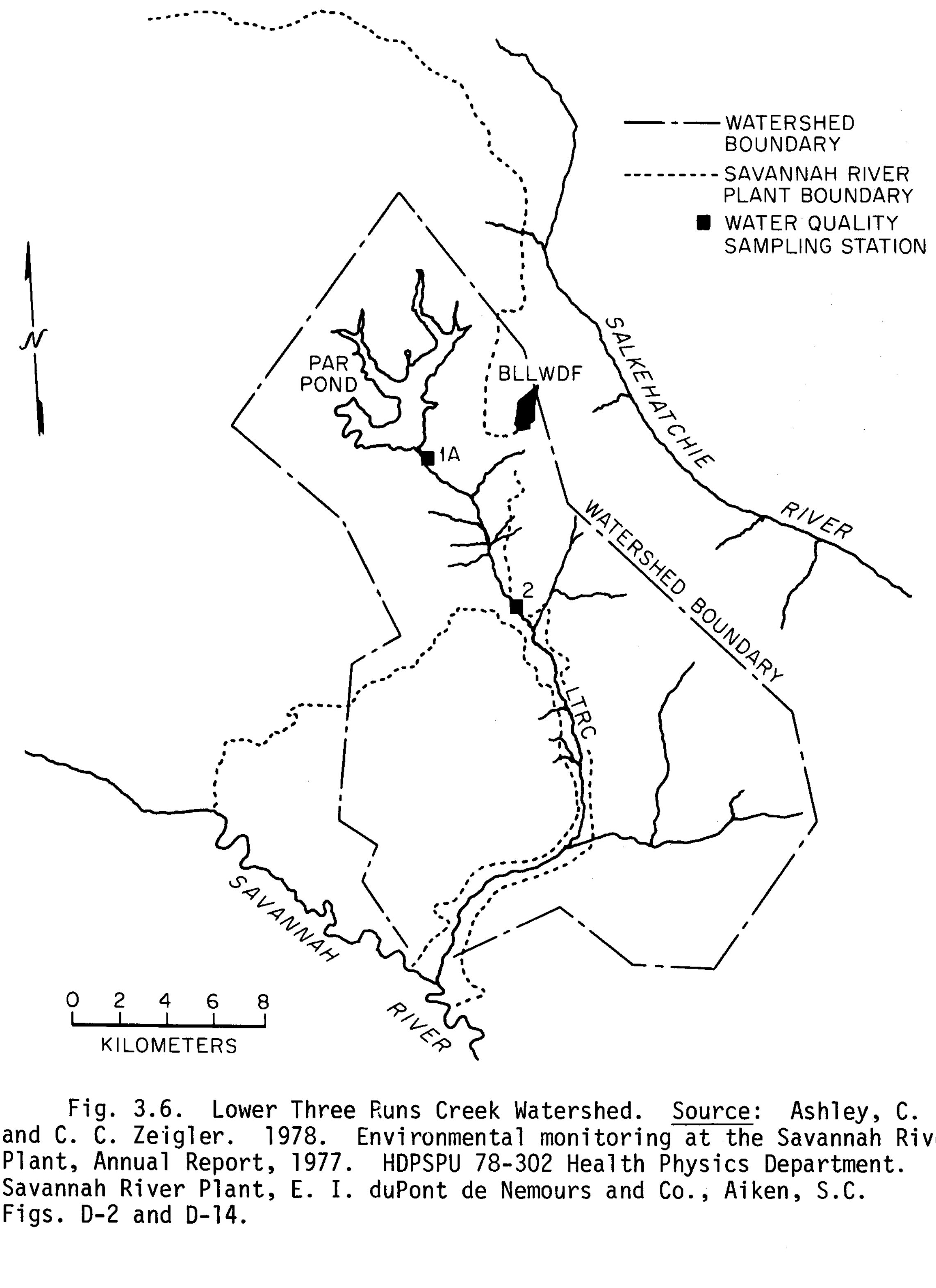

Fig. 3.6. Lower Three Runs Creek Watershed. Source: Ashley, C. and C. C. Zeigler. 1978. Environmental monitoring at the Savannah River Plant, Annual Report, 1977. HDPSPU 78-302 Health Physics Department. Savannah River Plant, E. I. duPont de Nemours and Co., Aiken, S.C. Figs. D-2 and D-14.

tributary of the Savannah River, with about 98% of the drainage flowing toward the Savannah River. Lower Three Runs Creek, which is about 4.6 km (2.9 mi) south of the facility, is 43 km (27 mi) in length with the upper 11 km (7 mi) blocked by a dam forming an impoundment referred to as Par Pond (EA, p. 8 and 9). The low elevation and reduced topographical relief of the area produces a relatively slow flowing stream with an average width of 30 ft (9.8 m). The strong variation in average flow rates with season [0.14 cms (5 cfs) in summer to 1.42 cms (50 cfs) in late winter] results in significant lateral displacement of water across the flood plain during winter flooding (ref. 24 and EA, p. 9). Flows gauged by the U.S. Geological Survey between July, 1958, through August, 1968, showed a maximum flow rate of 14.2 cms (500 cfs).[23]

There are no flowing streams or any other form of direct surface drainage to LTRC from BLLWDF. The closest tributary of LTRC is Mary's Creek that originates as a small but constant flowing spring about 0.9 km (0.6 mi) south of the BLLWDF boundary. The subsurface water table flow appears to be primarily in a southward direction toward Mary's Creek and LTRC below Par Pond (Fig. 3.7).

The topography of the site is gently rolling with the grade elevation ranging from 73 to 80 m (240 to 260 ft) MSL. The elevation of Par Pond is 61 m (200 ft) MSL and the elevation of LTRC is about 43 m (140 ft) MSL. Because of the major elevation differences flooding of the site is considered impossible (EA, p. 9-10).

Precipitation at the site averages about 119 cm (47 in.) per year (Sect. 3.1.3). Most surface run-off from the trench area is directed by gravity flow away from existing trenches and collected for evaporation in a Carolina bay or a holding basin on the western section of the site. Some water also settles in areas being excavated for fill material (personal observation from site visit). The Carolina bay is gradually being filled with soil, but its water holding and evaporation function has been recently replaced by a holding basin along the western boundary of the site. A small grassy depression (a former Carolina bay) on the southeast corner of the site is connected by underground pipes to the Carolina bay on the western side and can serve as an additional area for water collection and evaporation (EA, p. 130). Neither Carolina bay contains water for sufficiently long enough periods to be considered as aquatic habitats, although the larger one may have supported temporary pond communities prior to filling.

It appears that most, if not all, of the runoff from rainfall on the trench areas would be contained onsite currently. Some runoff from along roads on the outer margins of the site and from the office complex area on the south would drain into roadside depressions. Currently, surface water recharge to the groundwater is expected to be the only mechanism for association of surface water on the BLLWDF site with Mary's Creek and LTRC. Site closure and stabilization plans, however, call for filling the water collection ditch with soil, allowing runoff to flow toward roadside drainage ditches, culverts, etc. At this time, heavy rainfall may result in surface runoff to Mary's Creek or LTRC.

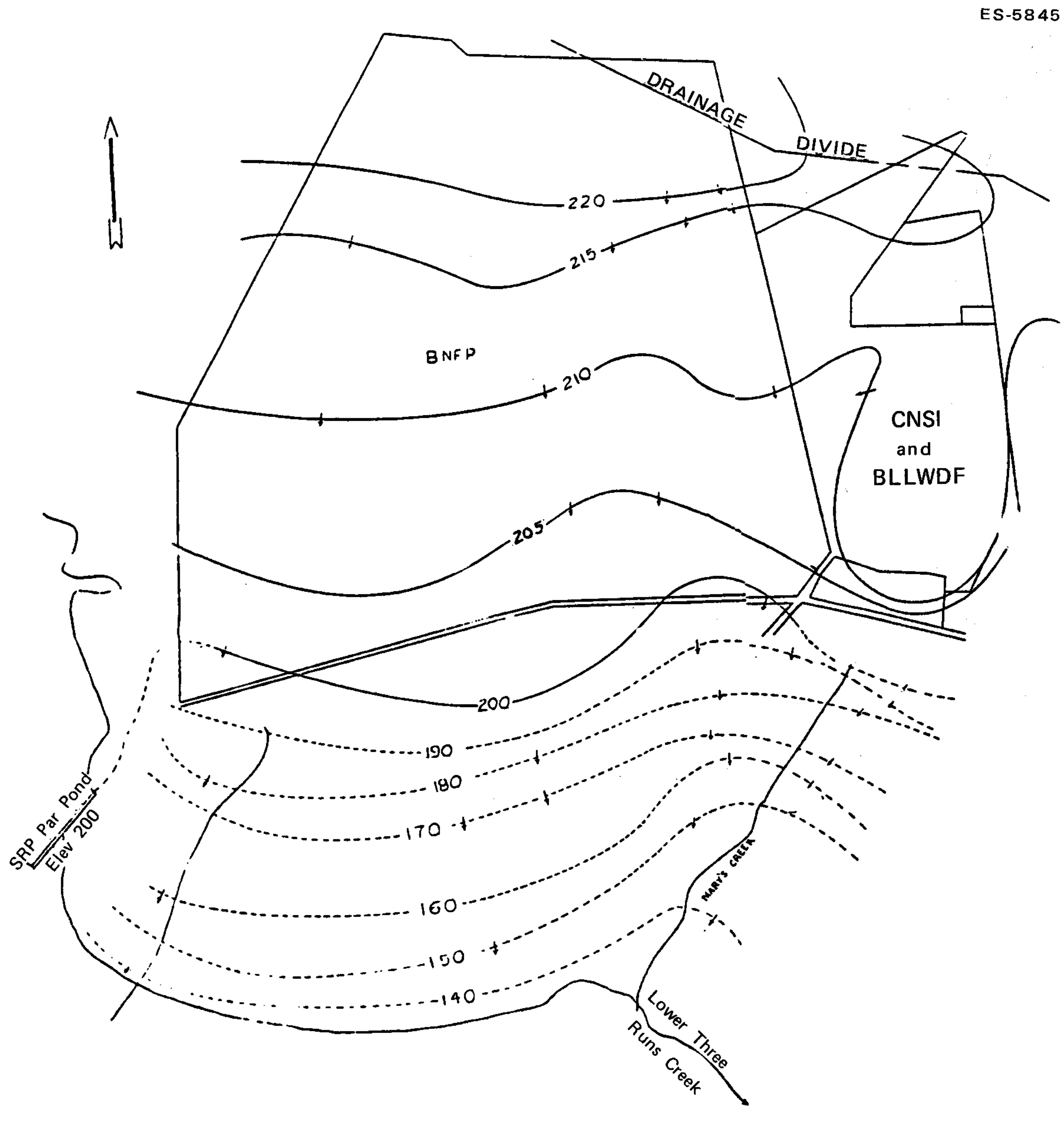

Fig. 3.7. Subsurface water table of Barnwell low-level waste disposal facility (BLLWDF) and adjacent area. Source: *Preliminary Site Stabilization and Closure Plan for the Barnwell Low-Level Radioactive Waste Disposal Facility*, Chem-Nuclear Systems, Inc., May 1980.

Water quality data are routinely collected on LTRC by the Health Physics Department at SRP at sampling stations depicted in Fig. 3.6. The most recently published data are presented in Table 3.20. Most parameters were sampled once per month during 1977 and duplicate analysis of each sample was performed in the laboratory using routine procedures.[25] The wide differences in maximum and minimum values as well as the large standard deviation around the mean can most likely be attributed to seasonal variation. Considering the 10X difference in average flow rates over a year's time, most parameters would be expected to vary. The station below Par Pond receives only seepage through the earthen dam during low flow periods and overflow from the dam during higher flow periods. The Patterson Mill Station is probably more representative of water quality throughout the stream because several springs augment the flow above that station.

The water quality data indicate that the stream has relatively soft water with a probable tendency toward acid conditions which is typical of "black water streams" of the coastal plains. The dissolved oxygen condition of the stream at Patterson Mill Bridge exceeds, year round, the standard established by the state of South Carolina for the highest stream classification,[26] which indicates the stream does not suffer biological pollution problems. The maximum parameter values indicated for pH, total dissolved solids, nitrate, and sulfate are well below or within the limits established by the Federal government for drinking water standards.[27] Mean iron level is only slightly above the Federal secondary drinking water standards.[28]

3.6.2 Groundwater

3.6.2.1 Regional flow system

Groundwater in Barnwell county occurs mainly in unconsolidated and partly consolidated formations of Cretaceous and Tertiary age. The regional dip and alternative sequence of permeable sands (aquifers) and relatively impermeable dense clays (aquicludes) probably accounts for the artesian conditions present in some of these formations downdip from the outcrop area.

The pre-Mesozoic metamorphic and igneous rocks underlying Barnwell county are dense and relatively impermeable and characteristically only yield small quantities of water.

The Tuscaloosa and Ellenton formations of Cretaceous age are hydrologically connected and are referred to as a single aquifer. This is the principle aquifer in the region, and large supplies of groundwater are available with wells yielding as much as 126 L/s (2000 gpm).[29]

Overlying the Tuscaloosa aquifer is the McBean-Congaree formation of Tertiary age. Beds of sand and limestone in the lower part of the formation are fairly permeable and yield moderate to sizable quantities of water. Yields from wells tapping the more permeable parts of this formation range from 3.8 to 41.7 L/s (60 to 660 gpm).[29]

Table 3.20. Water quality of Lower Three Runs Creek, 1977, in mg/L unless otherwise noted

Parameter	No. of analysis	Maximum	Minimum	Arithmetic Mean	Arithmetic 2 standard deviation
Station 1A—below Par Pond					
Water volume, L		2.639E10 (total)			
Temperature, deg C	12	29.000	10.000	20.167	+/–13.262
pH	12	8.400	3.300		
Dissolved oxygen	12	12.400	3.200	7.642	+/–5.118
Alkalinity	11	22.000	13.000	17.273	+/–5.871
Suspended solids	12	85.000	1.000	15.667	+/–47.193
Volatile solids	12	41.000	10.000	20.167	+/–18.970
Total dissolved solids	12	82.000	35.000	50.917	+/–26.825
Total solids	12	141.000	37.000	66.583	+/–62.729
Fixed residue	12	72.000	10.000	39.000	+/–34.954
BOD	3	1.900	<1	1.067	
COD	12	19.000	<5	7.417	+/–9.815
Kjeldahl, N	3	1.000	<1	<1	
Chloride, Cl	12	5.500	4.000	5.025	+/–0.778
Nitrite, N	12	<0.02	<0.02	<0.02	
Nitrate, N	12	0.090	<0.02	<0.02	+/–0.051
Sulfate, SO_4	11	9.000	<2	3.273	+/–5.733
Sulfide, S	12	<1	<1	<1	
Orthophosphate, P	10	0.030	<0.02	<0.02	+/–0.023
Total phosphate, P	10	0.160	<0.02	0.039	+/–0.099
Aluminum, Al	11	<0.5	<0.5	<0.5	
Ammonia, N	10	0.950	<0.1	0.217	+/–0.670
Calcium, Ca	11	9.100	2.200	4.736	+/–3.694
Sodium, Na	11	4.900	1.300	4.064	+/–2.253
Total iron, Fe	11	1.600	<0.1	0.564	+/–0.969
Lead, Pb	11	<0.5	<0.5	<0.5	
Station 2—Patterson Mill Bridge					
Water volume, L		8.028E10 (total)			
Temperature, deg C	12	25.000	6.000	17.083	+/–13.973
pH	12	7.300	3.900		
Dissolved oxygen	12	11.800	6.400	8.583	+/–3.459
Alkalinity	11	37.000	17.000	28.273	+/–11.733
Suspended solids	12	85.000	1.000	16.417	+/–47.768
Volatile solids	12	41.000	9.000	24.333	+/–17.296
Total dissolved solids	12	83.000	51.000	60.750	+/–18.530
Total solids	12	141.000	52.000	77.250	+/–49.720
Fixed residue	12	109.000	10.000	49.667	+/–46.400
BOD	3	1.600	<1	<1	
COD	12	62.000	6.000	17.333	+/–34.927
Kjeldahl, N	3	<1	<1	<1	
Chloride, Cl	12	4.000	2.500	3.550	+/–0.978
Nitrite, N	12	0.010	<0.02	<0.02	+/–0.006
Nitrate, N	12	0.140	0.030	0.074	+/–0.063
Sulfate, SO_4	11	3.000	2.000	2.636	+/–1.009
Sulfide, S	12	<1	<1	<1	
Orthophosphate, P	10	0.020	<0.02	<0.02	+/–0.013
Total phosphate, P	10	0.090	<0.02	0.035	+/–0.055
Aluminum, Al	12	5.000	<0.5	0.708	+/–2.906
Ammonia	10	0.060	<0.1	<0.1	+/–0.041
Calcium, Ca	12	13.600	0.700	8.892	+/–6.923
Mercury	0				
Sodium, Na	12	4.800	1.900	3.017	+/–1.377
Total iron, Fe	12	2.700	<0.1	0.662	+/–1.696
Lead, Pb	12	<0.5	<0.5	<0.5	

Source: C. Ashley and C. C. Zeigler, *Environmental Monitoring at the Savannah River Plant, Annual Report, 1977,* DPSPU 78-302, Health Physics Department, Savannah River Plant, E. I. duPont de Nemours and Co., Aiken, S.C.

Generally the Barnwell formation, of Tertiary age, does not yield large quantities of water to wells tapping this formation because of the presence of predominantly fine-grained sand and admixed amounts of silt and clay-sized particles.[29]

The Hawthorn formation, of Tertiary age and overlying the Barnwell formation, is also composed of fine-grained materials consisting of compacted silt and clay. This formation is generally incapable of yielding water and therefore not suitable for the construction of wells.[29]

3.6.2.2 Regional groundwater quality and use

Water obtained from most of the geologic formations described above is of excellent quality and is acceptable for most uses. Water from the lower portion of the Tuscaloosa aquifer is soft, slightly acidic, and unlikely to contain objectionable amounts of iron; however, water from the upper portion of the aquifer (Ellenton formation) is of the calcium sulfate type and is likely to contain objectionable amounts of iron. Water from the limestone bed of the McBean-Congaree formation is moderately hard and contains objectionable quantities of iron. Water from the Tertiary sands is generally not as soft and slightly more acidic than water in the lower portion of the Tuscaloosa aquifer.[29]

Groundwater in this area is used mainly for municipal, industrial, and domestic supplies.

The Tuscaloosa aquifer is used extensively as a source of groundwater. In addition, McBean-Congaree formation yields moderate to sizable quantities of water to industrial and municipal wells. The Barnwell and Hawthorn formations may supply limited quantities of water for domestic use.

3.6.2.3 Site flow system

According to the most recent study[30] performed at the site for Chem-Nuclear, groundwater at the site occurs under water table conditions in the Miocene sediments. However, Artesian conditions exist in the deeper aquifers, including the Eocene sediments. The top of the Tuscaloosa aquifer, which is estimated to be approximately 152 m (500 ft) beneath the surface of the site, is under artesian conditions and will not be affected by site operations.

A potentiometric surface map has been compiled using this most recent data and is presented in Fig. 3.8. This potentiometric surface map indicates that groundwater in the Miocene sediments beneath the site flows generally to the south and southwest. The groundwater table mimics the surface topography of the site and surrounding area in a general way. However, the staff has examined other recent data[31] and believes that the underlying surface of the tertiary sediments may be the predominant factor controlling the groundwater table beneath the site.

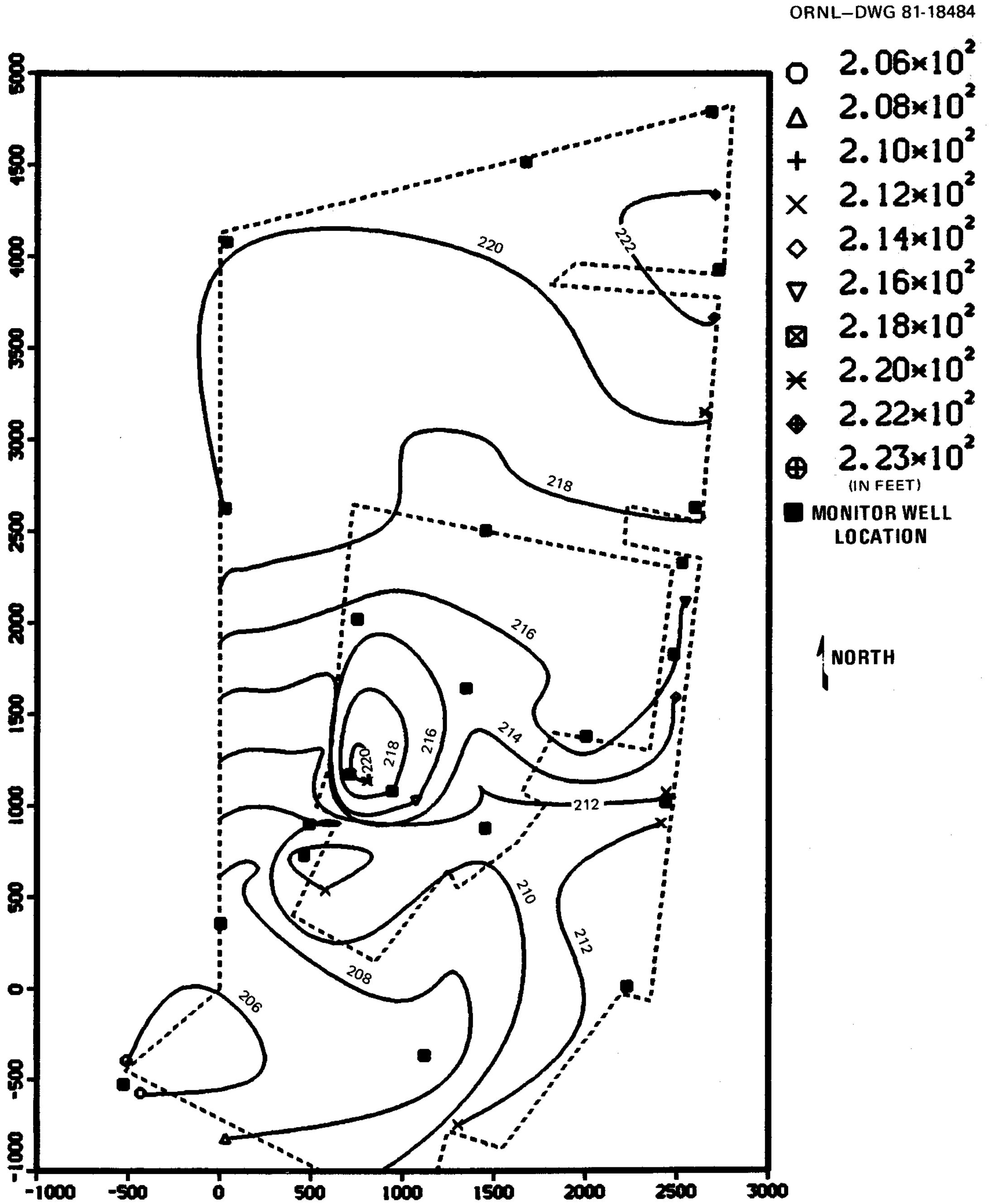

Fig. 3.8. Potentiometric surface map for Miocene sediments beneath the Barnwell site, June 1981.

As stated in Sect. 2.4.1, Condition 7 requires that Chem-Nuclear demonstrate that all trench bottom elevations are above water table levels, taking into account the complete history of seasonal fluctuations. To determine whether Chem-Nuclear was meeting this requirement, the thickness of the unsaturated soil between the surface topography and the potentiometric surface of the Miocene sediments was compiled and is presented in Fig. 3.9. If a trench depth of 6.7 m (22 ft) and a minimum distance of 1.5 m (5 ft) from the trench bottom to the top of the potentiometric surface is assumed, then at least 8.2 m (27 ft) of unsaturated soil is required to meet Condition 7. Figure 3.9 indicates that there is a sufficient thickness of unsaturated soil beneath the entire site except for possibly the extreme northeast corner. As trench burial operations progress toward this portion of the site, more detailed unvestigations should probably be initiated.

Data from a preoperational survey[32] found that the porosity of the Miocene sediments was about, 40% and the average permeability approximately 1.4×10^{-4} cm/sec (2.7×10^{-4} ft/min). Using these values the velocity of groundwater beneath the site is on the order of 2.2 m/year (7.3 ft/year).

In the same study,[32] grain size distribution analyses were determined for five soil samples from the Miocene sediments. These analyses indicate that on the average the sediments are composed of approximately 75% sands and 25% silts and clays. Petrographic analysis indicates that the sand fraction is composed predominantly of angular quartz and the silt and clay fraction of kaolinite.

Cation-exchange capacities were determined for four soil samples taken at the site.[32] The cation-exchange capacities ranged from 1.50 to 3.78 meg/100 g. These low cation-exchange capacities would be expected from a soil in which the sand fraction is composed almost entirely of quartz and the silt and clay size fraction is composed almost entirely of kaolinite.

3.6.2.4 Site groundwater quality

Chem-Nuclear has not supplied site-specific nonradiological groundwater quality data. However, data provided by the U.S. Geological Survey indicates that it is probably slightly acidic and has a low total dissolved solids content.[29,31]

3.7 GEOLOGY, MINERAL RESOURCES, AND SEISMICITY

3.7.1 Geology

3.7.1.1 Regional geology

The Chem-Nuclear site is located in west central South Carolina in Barnwell county. Geologically the site lies ∿72 km (45 miles) SE of the Piedmont Plateau and on the Coastal Plain Province (Fig. 3.10). Physiographically, most of Barnwell county lies on the Aiken Plateau.

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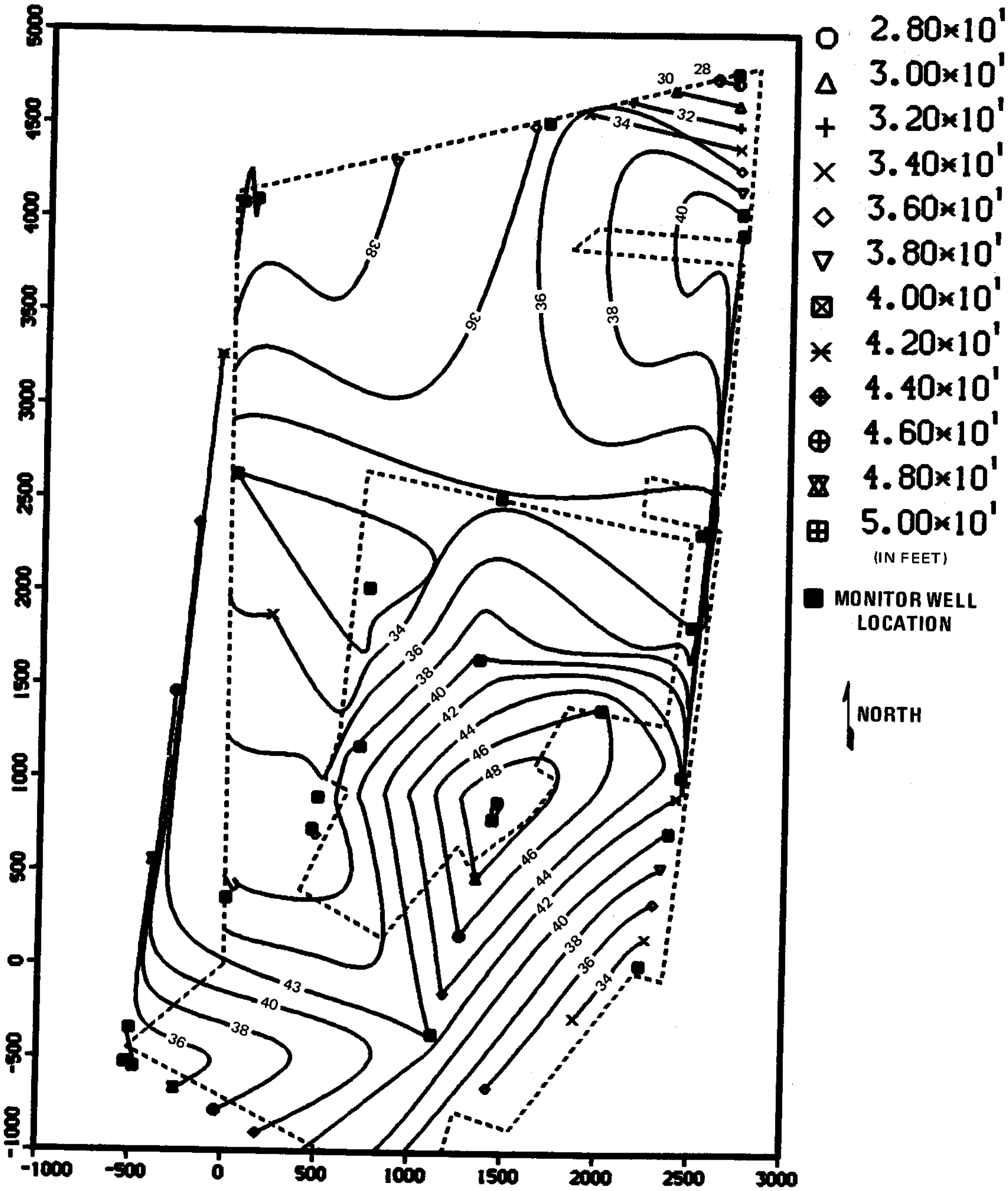

Fig. 3.9. Thickness of unsaturated soil between the topographic surface and potentiometric surface of the Miocene sediments, June 1981.

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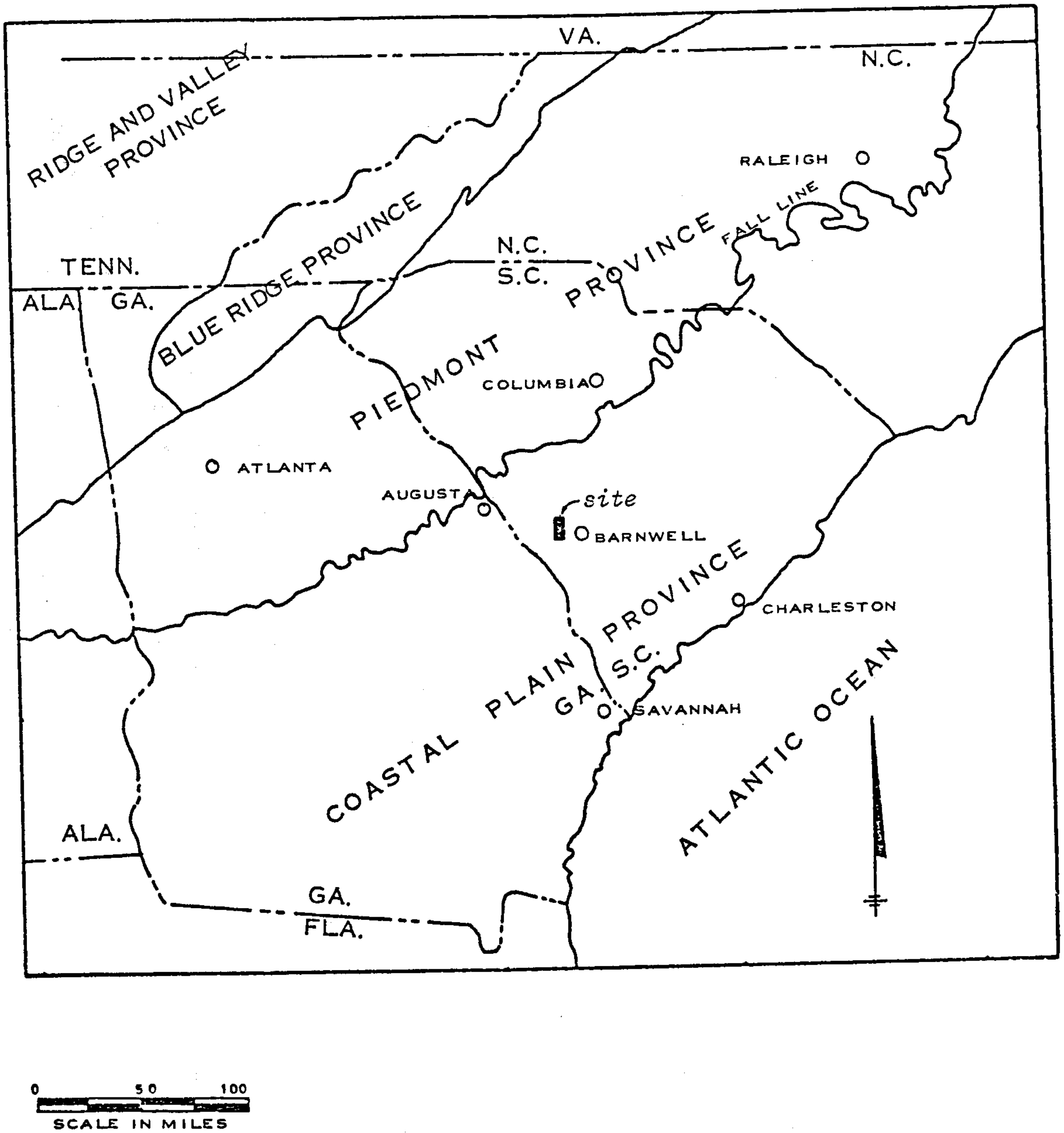

Fig. 3.10. Regional geological provinces. <u>Source</u>: *Report of Geologic and Hydrologic Studies Near Snelling, South Carolina,* Law Engineering Testing Company, Atlanta, October 1970.

3.7.1.2 Stratigraphy

Geological formations ranging in age from Eocene to Quaternary are exposed in Barnwell county. Underlying the sedimentary Eocene formations are rocks of Cretaceous age, Triassic and/or Jurassic age, and metamorphic and igneous rocks of pre-Mesozoic age. A stratigraphic column of this area is presented in Fig. 3.11.

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ERA	SYSTEM	SERIES	FORMATION
CENOZOIC	QUATERNARY TO TERTIARY	RECENT TO PLIOCENE	ALLUVIAL DEPOSITS
	TERTIARY	MIOCENE	HAWTHORN
		EOCENE	BARNWELL
			McBEAN-CONGAREE
MESOZOIC	CRETACEOUS	UPPER	ELLENTON
			TUSCALOOSA
	TRIASSIC	UPPER	NEWARK GROUP
PALEOZOIC AND PRECAMBRIAN			INGENOUS AND METAMORPHIC ROCKS

Fig. 3.11. Barnwell County stratigraphic column. Source: Compiled from George E. Siple, *Geology and Groundwater of Savannah River Plant and Vacinity, South Carolina,* U.S.G.S Water-Supply Paper 1841, Washington, 1967.

Metamorphic and igneous rocks of pre-Mesozoic origin crop out northwest of Barnwell county and underlie all of Barnwell county at depths greater than 274 m (900 ft).

Triassic and/or Jurassic sedimentary rocks occur as erosional remnants in downfaulted graben structures,[33] referred to as the Dunbarton Triassic Basin.

The Tuscaloosa formation, of late Cretaceous age, unconformably overlies the pre-Mesozoic metamorphic and igneous rocks, and the erosional remnants of Triassic and/or Jurassic age. This formation consists of tan, buff, red, and white crossbedded micaceous quartzitic and arkosic sand and gravel, interbedded with red, brown, and purple clay and white kaolin.[29]

The Ellenton formation, of late Cretaceous age, overlies the Tuscaloosa formation, probably unconformably, and consists of a dark-gray to black sandy lignitic micaceous clay interbedded with medium to coarse quartz sand.[29]

Overlying the late Cretaceous sediments is the McBean-Congaree formation of the Eocene series of the Tertiary system. This formation consists of yellow-brown to green fine to coarse glauconitic quartz sand, interbedded with green, red, yellow, and tan clay, sandy marl or limestone, and lenses of siliceous limestone.

The Barnwell formation, also of Eocene age, unconformably overlies the McBean-Congaree formation. The general appearance and lithology of this formation resembles that of a residuum of sandy limestone strata from which most of the calcareous material has been removed by solution. This formation is primarily composed of deep-red fine to coarse clayey sand and compact sandy clay.[29]

The Hawthorne formation of Miocene age is separated from the underlying Eocene sediments by an erosional unconformity. In the up-dip area of Aiken and Barnwell counties, this formation consists mainly of tan, reddish-purple, and gray sandy dense clay that contains coarse gravel and limonitic nodules.[29] The Hawthorne formation contains numerous clastic dikes (see Sect. 3.7.1.4).

Alluvial deposits of late Tertiary age occur irregularly and discontinuously on the interstream divides or plateaus. They are generally composed of coarse gravel and poorly sorted sand.[29]

Circular depressions, known as Carolina bays of undetermined origin occur throughout the area.

3.7.1.3 Regional geologic structure

The surface of the igneous and metamorphic rock complex of pre-Mesozoic age is erosional and dips to the southeast, beneath the Coastal Plain sediments, at approximately 11 m/1.6 km (36 ft/mile). Coastal Plain sediments from late Cretaceous to Quartenary age form a wedge varying in thickness from tenths of a meter (a few feet) to more than 366 m (1200 ft) (ref. 34) just southeast of the site. The site lies very close to a buried fault in the pre-mesozoic rocks along the southeastern side of the Dunbarton Triassic basin.[35]

3.7.1.4 Site geology

As indicated by a topographical map supplied by Chem-Nuclear, elevations range from a high of about 80 m (263 ft) above MSL in the northern portion of the site to a low of 73 m (239 ft) above MSL in the western portion of the site (Carolina bay).

A very sandy top soil covers the site and ranges in thickness from 0.61 m to 4.6 m (2 to 15 ft). Below this lies 15 to 18 m (49 to 59 ft) of Miocene sediments (Hawthorne formation). Below this, Eocene sediments were encountered, during preoperational drilling, to a depth of at least 45.7 m (150 ft) near the center of the site.

Several shallow depressions are located within the site boundary. A considerable number of opinions relating to the origin of these and other similar depressions may be found in the literature. One such theory supports the idea that the depressions represent collapse structures caused by the solution of calcareous materials near the base of the McBean formation of Eocene age. Boring B-30 was drilled during the preoperational survey[32] and towards the center of the Carolina bay near the western perimeter of the site. Results indicated that Miocene sediments were encountered at a lower elevation than would have been expected from extrapolation of other boring data.[5] Chem-Nuclear is of the opinion that this lends support to the hypothesis that some leaching of calcareous materials has occurred causing the soils above the leached zone to subside.

3.7.1.5 Structural site geology

As stated previously, the Hawthorne formation in this area contains numerous clastic dikes. A detailed investigation was performed related to the origin of these clastic dikes and some fault offsets reported in a few of the trenches at Chem-Nuclear.[33] This investigation concluded that the processes responsible for the formation of the faults and dikes in this locale have been inactive for a considerable period of time (at least 10,000 years) and that the presence of these dikes and faults does not violate the integrity of the waste burial trenches. The staff agrees that the presence of these dikes and faults does not violate the integrity of the waste burial trenches.

3.7.2 Mineral resources

Possible mineral resources that are likely to be found in this region include lignite and kaolinite. This area may also have limited potential for hydrocarbon development and as an extremely low grade uranium/thorium resource (Chem-Nuclear, February 12, 1981).

3.7.3 Seismicity

A recent probabilistic acceleration map of the contiguous United States (see Fig. 3.12) indicates that the horizontal acceleration (as a result of earthquake activity) that could be expected at the Chem-Nuclear facility, with a 90% probability of not being exceeded in 50 years, is about 0.10 gravities. The historical record indicates that only one significant ground shaking event occurred in the Barnwell area over the last three centuries. This was the result of the 1886 Charleston, South Carolina earthquake centered 134 km (83 miles) southeast of the site. This event produced an estimated intensity of VI-VII (modified Mercalli scale) in the Barnwell area.

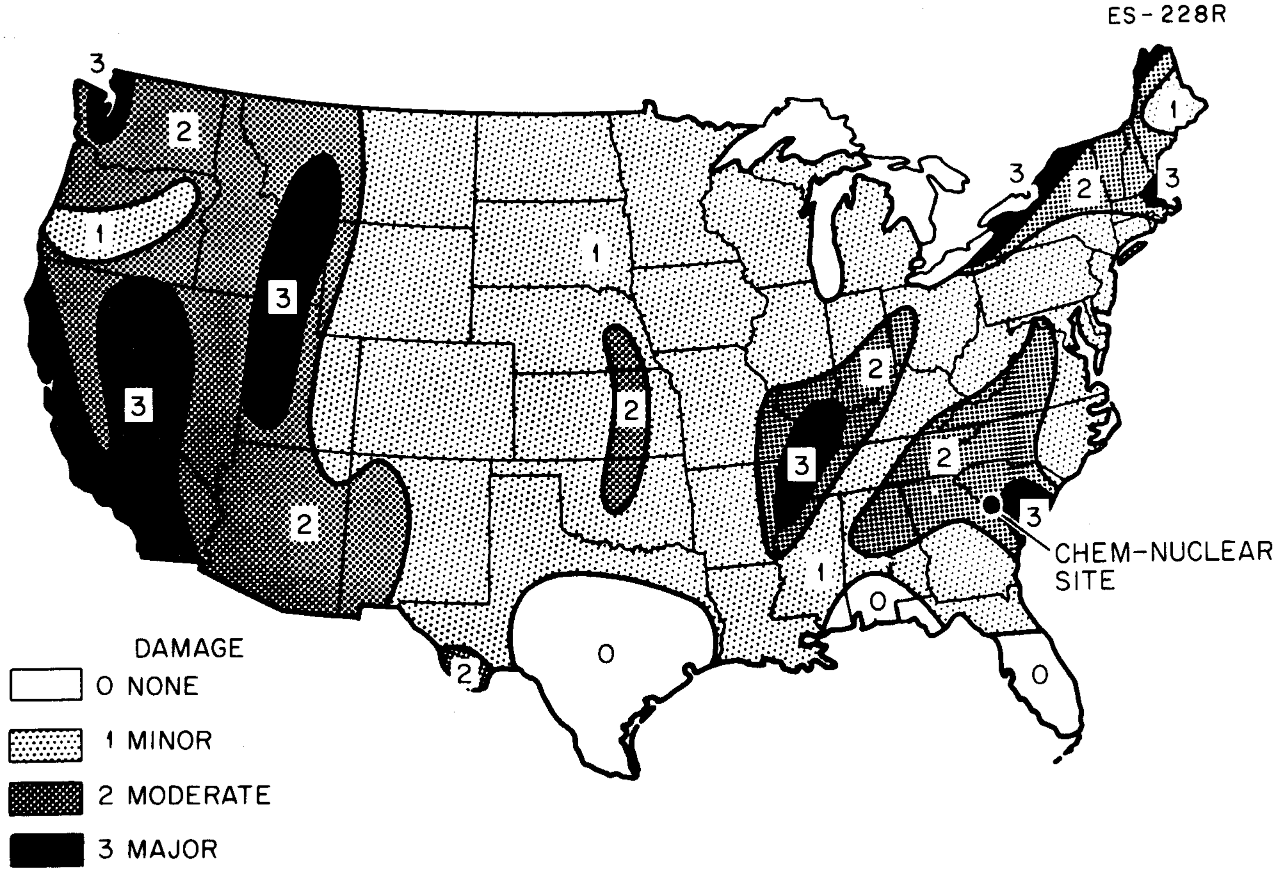

Fig. 3.12. Seismic risk map for the conterminous United States.

Although slight damage could occur to the trenches from such an event (minor breaching of clay trench cap) the staff feels that the basic physical and hydrological integrity of the trenches would not be endangered.

3.8 SOILS

The Barnwell County Soil Survey[36] indicates that seven soil mapping units occur on the waste disposal site. The percentage of the Barnwell site covered by each soil is shown in Table 3.21. A dot grid was superimposed on the soils map of the site[36] to estimate the percentages. Blanton sand, Fuquay sand, and Lakeland sand cover approximately 84% of the area. These soils occur on level to gently sloping areas, are droughty, are susceptible to rapid leaching of plant nutrients, are severely to moderately limited for agricultural production, and have moderate to high potential woodland productivity. Three other soils, Plummer loamy sand, Lumbee loamy sand, and Rembert loam, all exhibit water problems such as ponding, flooding, and/or high water tables. They occur in low, wet, sandy flats, in level depressions, or in low, flat, oval-shaped bays (Carolina Bays). The three soils are severely limited

Table 3.21. Soils of the Barnwell LLWDF site, as percentage of surface area covered by each map unit

Map Unit	Coverage
Blanton sand	34
Fuquay sand	28
Lakeland sand	22
Plummer loamy sand	1
Lumbee loamy sand	5
Rembert loam	1
Dotham loamy sand	8

for agricultural production because of the moisture problems. However, they have high potential woodland productivity for tree species adapted to wet environments. The final soil on the site, Dothan loamy sand, is deep and well-drained, occurs on uplands, has moderate available water capacity, has moderate limitations for agricultural production, and high potential for woodland productivity.[36]

Two soils which have limited occurrence on the site deserve special mention. Dothan loamy sand covers a small area, 8% (Table 3.21), but it has been classified as prime and unique farmland (Don Halbick, State Soil Scientist, USDA, SCS, February 13, 1981). The Rembert loam, which covers only 1% of the area (Table 3.21) is the soil of a Carolina bay which occurs on the site.

3.9 BIOTA

3.9.1 Terrestrial Biota

The terrestrial biota of the Barnwell area is well-known because of it's proximity to the SRP (Fig. 3.5). Research on the SRP began on a limited basis in 1951 and has continued to the present. The Savannah River Ecology Laboratory (S.R.E.L.), established on the SRP in 1961, has conducted extensive ecological research on the reservation. Langley and Marter's 1973 summary of the early research[8] provides a good overview of the terrestrial biota of the SRP and surrounding areas. Several other references are useful for describing the terrestrial biota in the vicinity of the site.[18,23,37,38] A ten-year study conducted by scientists from Emory University describes the ecology of the site of the AGNS facility which is adjacent to the waste disposal site[24] (Fig. 3.5). Much of the description of the terrestrial biota of the Barnwell area is modified from this report.[24]

3.9.1.1 General

The composition of the terrestrial ecosystems in Barnwell area, although determined by several interacting environmental factors, seems to be related primarily to elevation, topography, soil characteristics, and patterns of previous land use. These factors interact to produce habitats varying from very sandy, dry uplands to continuously-flooded swamps. Organic matter tends to accumulate in low-lying areas, and it provides sufficient nutrients to support dense forests. On upland sites, the combination of nutrient-limited soils and xeric (dry) conditions prevent the development of dense forest systems.

The following upland terrestrial ecosystems occur in the vicinity of the waste disposal site: pine-scrub oak forest, loblolly and mixed pine forest, pine-oak forest, Carolina bays, and old fields.[24] In addition to these systems, planted pine forests are also abundant in the area.

Prior to its development as a waste disposal facility, the 121 ha (300 acres) site was utilized primarily for pulpwood production and agriculture. Ninety-five ha (235 acres) of the site have been designated as an exclusion area, and approximately 60% of the forest has been cleared from this area. Approximately 16 ha (40 acres) of the exclusion area have been used for waste burial (EA, p. 1). As additional disposal capacity is needed, most of the remaining forested area will be cleared to provide space for trench excavation. In its current condition, the site consists of a large cleared area for waste disposal trenches, small vegetated areas that are primarily planted loblolly pine with occasional inclusions of pine-scrub oak forest and pine-oak forest, and the remnants of a Carolina bay which is being backfilled by onsite activities (Staff inspection of the site on Feb. 12, 1981). The composition of the four terrestrial ecosystems occurring on the site is described below.[24]

3.9.1.2 Planted loblolly pine

These forests are managed for pulpwood production. However, they do share ecological characteristics with natural loblolly (*Pinus taeda*) forests found in the area.[24] Animal diversity is low in these systems, however, a few vertebrates, including several insectivorous birds, anole lizards, and pine snakes and red-bellied snakes, may occur in these forests.

3.9.1.3 Pine-scrub oak forest

These forests are characterized by the presence of longleaf pine (*Pinus palustris*), turkey oak (*Quercus laevis*), and bluejack oak (*Q. cinera*), and they occur in upland xeric habitat called "sand hills."[24] Vertebrates are quite rare in these forests; however, anole and fence lizards, a few insectivorous birds, and possibly, foxes may be found.

3.9.1.4 Pine-oak forests

This is the most abundant forest type in the region and occurs in areas located between bottomlands and extreme upland sites. Canopy dominants are widely-spaced loblolly and longleaf pines. The lower sub-canopy is composed of various oak species. Vertebrates are generally rare in these forests. Bird density is typically low; however, cottonmice, squirrels, rabbits, and possibly deer or foxes may be found.

3.9.1.5 Carolina bays

Carolina bays are undrained upland depressions. Varying in depth, they may support natural systems such as ponds, swamp forests, and herbaceous vegetation. Animal populations associated with the bays are fairly diverse. Large numbers of tree frogs and cricket frogs are found in bays during their late winter through spring breeding season. These and several other amphibians, several bird species, and small snakes occur in this habitat. Large predators including hawks, owls, snakes, weasels, and foxes prey on cotton rats or amphibians along the margins of Carolina bays.[24]

All of the ecosystems described above occur on upland land forms. Several important lowland ecosystems occur in the area but not on the waste disposal site. The two most important are floodplain swamp forests and stream bank forests which occur in association with Lower Three Runs Creek.[24] They will not be described in this assessment since they do not occur on the waste disposal site.

3.9.1.6 Endangered and threatened species

The endangered and threatened animal species that may occur in the Barnwell area are listed in Table 3.22. These species are on the U.S. Fish and Wildlife Service list[39] and/or protected by South Carolina law.[40]

The three Federally listed plant species in South Carolina[39] are not known to occur in the Barnwell area (Dr. Douglas Raynor, South Carolina Heritage Trust Program, Feb. 13, 1981). However, several plant species in the state are under review by the U.S. Fish and Wildlife Service and should be considered in environmental planning.[41] Plants under review which are likely to occur in the Barnwell area have been identified by Dr. Douglas Raynor (South Carolina Heritage Trust Program, Feb. 13, 1981) and are listed in Table 3.22. Although South Carolina has a state list of endangered and threatened plant species, they are not protected by law.[42]

Table 3.22. Endangered and threatened plant and animal species of the Barnwell, South Carolina area

Species	Habitat
Plants	
Echinacea laevigata[a] (purple coneflower)	Meadows and woodlands
Elliottia racemosa[a] (Georgia plume)	Sand ridges, oak ridges sandstone outcrops
Ilex amelanchier[a] (holly)	Wooded streambanks, mostly in sandhills
Myriophyllum laxum[a] (loose watermilfoil)	Sinks and pools
Nestronia umbellula[a] (sandalwood)	Woodlands, thought to be parasitic on pine tree roots
Oxypolis canbyi[a] (dropwort)	Streambanks, swamp forests and savannahs
Ptilimnium nodosum[a] (rose's bishopweed)	Savannahs, wet ditches
Sporobolus teretifolius[a] (dropseed)	Savannahs
Animals	
Picoides borealis[b] (red-cockaded woodpecker)	Open stands of mature southern pines
Haliaeetus leucocephalus[b,c] (bald eagle)	Near lakes and rivers
Elanoides forficatus[c] (swallow-tailed kite)	River swamps in Coastal Plain
Alligator mississippiensis[b] (American alligator)	River systems, lakes and swamps
Gopherus polyphemus[c] (gopher tortoise)	Pine-turkey oak, sandhill communities
Hyla andersonii[a,b] (pine barrens tree frog)	Sand hills region
Felis concolor cougar[b,c] (Eastern cougar)	Large wild areas with adequate food supply including deer and small mammals

[a] Federal status under review.

[b] Federal list.

[c] South Carolina list.

Sources: U.S. Department of the Interior, "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 45(99):33768-33781 (1980); U.S. Department of the Interior, "Endangered and Threatened Wildlife and Plants: Review of Plant Taxa for Listing as Endangered or Threatened Species," *Fed. Regist.* 45(242):82480-82569 (1980); South Carolina Nongame and Endangered Species Conservation Act, 1974(58)2384, Article 5, Rule 123-150; and A. E. Radford et al., *Manual of the Vascular Flora of the Carolinas,* The University of North Carolina Press, Chapel Hill (1968).

3.9.2 Aquatic biota

The nearest flowing water system which could potentially be affected by BLLWDF is Lower Three Runs Creek and its tributary, Mary's Creek (Fig. 3.6). No information is available on the aquatic biota of Mary's Creek, but its small size [less than 1 m (3.1 ft) wide near its source, personal observation] probably limits the diversity of animal species.

Lower Three Runs Creek is a typical black water stream with high tannin and lignen content. Aquatic biota have been surveyed for several years at Donora station, just upstream of Mary's Creek and at Patterson Mill Bridge a few kilometers below the mouth of Mary's Creek.[43-45] Information from those surveys and from observations by Emory University and AGNS personnel has been well summarized in previous studies[24-47] and is discussed below.

The food chains of LTRC are based predominantly on leaf litter from the surrounding stream bank forest and vegetation beds in the stream. The dominant emergent plants in LTRC, dotted smartweed (*Polygonum punctatum*) and stout smartweed (*P. desiflorum*), occur in extensive vegetation zones along the length of LTRC. The vegetation beds frequently extend from the stream bank into the channel with the size and extent varying considerably between years.

The predominant invertebrates found in LTRC include freshwater snails (*Campeloma sp.*), freshwater shrimp (*Palaemonetes paludosus*) and crayfish (*Procambarus hirsutus*). Aquatic insects are abundant including several species of midges, mayflies, and stoneflies. Invertebrate predators include dragonflies, damselflies, whirilgig beetles, and fishing spiders. Seven species of freshwater bivalve mussels are also found in the stream, *Ellipito complanata* being the most abundant.[48]

Although many species of amphibians, reptiles, and mammals are commonly associated with aquatic habits, the predominant species in the area have already been discussed under terrestrial biota in Sect. 3.9.1. Vertebrates considered in this section will be limited to fish. The most abundant fish collected in LTRC include gamefish such as dollar sunfish (*Lepomis marginatus*), red breasted sunfish (*L. auritus*) and bluegill (*L. macrochirus*) as well as nongame fish including the pirate perch (*Aphredoderus sayanus*). Other game fish such as black crappie (*Pomoxis nigromaculatus*) are fairly abundant and warmouth (*Lepomis gulosus*) occur occasionally.

Surveys of the biota of LTRC[43-47] have not identified any species which are included on either Federal[49] or state[33] listings of threatened and endangered species.

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4. ENVIRONMENTAL CONSEQUENCES

4.1 MONITORING PROGRAMS AND MITIGATING MEASURES

4.1.1 Existing monitoring systems

4.1.1.1 Surface water

No routine radiological monitoring of onsite surface water has been undertaken. However, samples of onsite surface water in drainage ditches and evaporation ponds are periodically collected and analyzed. Onsite surface water is available only on an intermittent basis and, therefore, a routine sampling schedule is inappropriate. Chem-Nuclear and the DHEC monitor offsite surface water according to a set schedule (see Sect. 2.3.5).

4.1.1.2 Groundwater

An ongoing monitoring program at the site is based on the original pre-operational study conducted for Chem-Nuclear. However, the monitoring data acquired over the life history of the site are not currently in a trended form so that a comprehensive assessment using original background data vs past and current data is not possible. These data are currently being assembled and plans call for having a trended report in final form in 1981.

The Barnwell facility is also currently revising the onsite groundwater monitoring program and is in the process of establishing an offsite groundwater monitoring program to improve the overall scope of environmental surveillance at the site. Such revisions include changes in well designations and sampling schedules and the installation of a permanent network of monitor wells along the site boundary.

The revised onsite monitoring plan, which is currently being implemented, will include ten permanent site-boundary wells along the perimeter of the site (Fig. 4.1). Each monitoring site will include one deep well that will penetrate the water table. Additionally, one well will be emplaced in each identifiable sandy interval greater than 1 m (3 ft) in thickness that was encountered during drilling of the original deep well. All wells shall be constructed (grouted and sealed) to ensure that incursions from strata above or below are of a very low probability. The frequency of sampling, type of sample, and type of radiological parameters are listed in Table 4.1. Monitoring within the site is conducted using approximately 50 onsite monitoring wells. Wells have been installed within 7.6 m (25 ft) of trenches 1 through 13. Cluster monitor wells (as described previously) have been installed strategically throughout the entire site. These wells are sampled on a quarterly basis (Table 4.1).

Observation sumps within individual disposal trenches allow monitoring for both trench fluid levels and fluid contamination. The sumps are monitored monthly (see Table 4.2) to determine if any water has collected

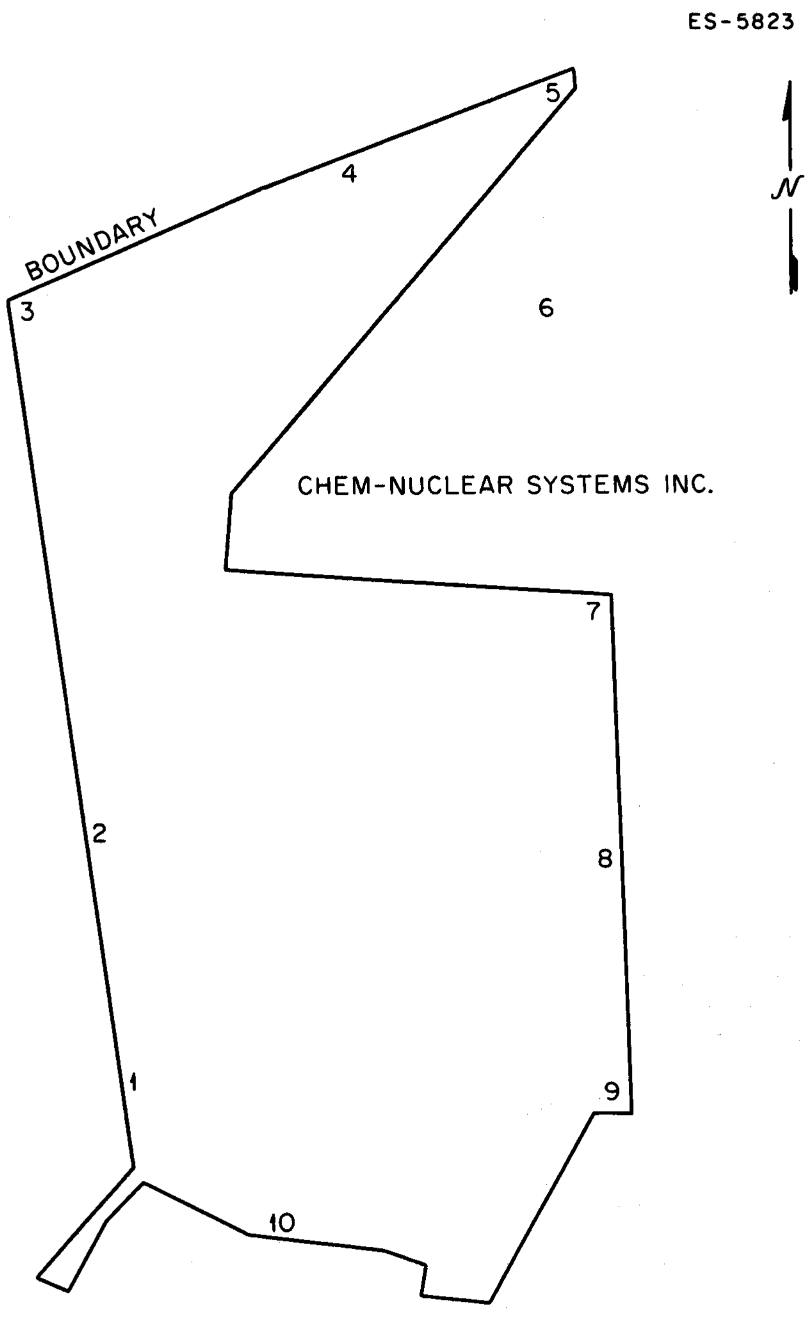


Fig. 4.1. Planned permanent environmental monitoring locations. (# = permanent onsite sampling locations).

Table 4.1. Onsite sampling schedule

Sample description	No. of locations	Type	Media	Frequency of analysis	Type of analysis
External gamma	40	Continuous	TLD	Quarterly	Exposure
Atmospheric	10 (site) 1 (offsite)	Continuous	Particulate filter	Weekly	Gamma isotopic, gross alpha/beta,
			Charcoal cartridge	Weekly	Iodine-131
Soil	10	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Vegetation	10	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Site boundary wells[a]	10 (3 per location	Grab		Semi-annual	Gamma isotopic, Gross alpha/beta HTO
Monitor wells[b]	50	Grab	Water sediment	Quarterly	Gamma isotopic, gross alpha/beta, HTO
Observation[c] sumps	40 (estimated)	Grab	Water sediment	Quarterly (when available)	Gamma isotopic, gross alpha/beta, HTO
Potable wells	3	Grab		Quarterly	Gamma isotopic, gross alpha/beta, HTO
Pumping station	3	Grab		As required	Gamma isotopic, gross alpha/beta, HTO

[a]Water level measured quarterly.
[b]Water level measured monthly.
[c]Sumps checked monthly.

Table 4.2. Offsite sample schedule

Sample description	No. of locations	Type	Media	Frequency of analysis	Type of analysis
Offsite wells	4	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Offsite water springs	3	Grab		Annual	Gamma isotopic, gross alpha/beta, HTO
Offsite potable wells	7	Grab		Annual	Gamma isotopic gross alpha/beta, HTO
Offiste open water, Mary's Creek Grist Mill	2	Grab	Water sediment	Annual	Gamma isotopic gross alpha/beta, HTO
Offsite soil (water springs)	3	Grab		Annual	Gamma isotopic gross alpha/beta, HTO
Offsite vegetation (water springs)	3	Grab		Annual	Gamma isotopic gross alpha/beta, HTO

in the trench. Grab samples of sediment or water, if present, are taken quarterly (or as necessary). New sumps permit dewatering of disposal trenches if necessary.

The offsite monitoring program is currently being established. Three natural springs have been identified near the site and will be sampled. Four offsite wells and seven offsite potable wells will also be sampled (see Table 4.2). Data from these wells will be used to supplement data gathered from the permanent site-boundary wells.

In addition to the Chem-Nuclear groundwater monitoring programs, groundwater monitoring is currently being or has been performed in the site area by two neighboring nuclear facilities (AGNS and SRP) and by the DHEC. The DHEC monitors thos groundwater sites indicated in Table 4.2.

The staff notes that the existing groundwater monitoring program does not call for the monitoring of nonradiological parameters. Based on information in the recently published document, *Study of Chemical Toxicity of Low-Level Wastes*,[1] the staff believes that attention should be given to the possibility of transport of hazardous chemicals and other inorganic species from the burial trenches at Barnwell. Waste materials at all LLW disposal sites contain a wide variety of toxic chemicals associated with radioactive wastes. These range from organic solvents and scintillation liquids derived primarily from non-fuel-cycle wastes to uranium-contaminated calcium fluoride, filters, spent ion exchange resins, etc., associated with the fuel-cycle wastes.[1] A summary of chemicals which may be found in LLW burial sites is given elsewhere.[1] Whether the burial ground trenches at BLLWDF contain such an array of substances is unknown.

The (EA, p. 39, 40) indicates that currently no liquid wastes, particularly no organic solvents, are accepted for burial; however, prior to 1978, infrequent shipments of liquid organic solvents such as scintillation vials were accepted. Currently 75% by volume of wastes accepted at Barnwell are low-level fuel cycle wastes with non-fuel-cycle wastes comprising the remainder. Thus, although inorganics and elemental species associated with fuel-cycle wastes are likely to predominate, organic compounds may also be present.

The burial trenches probably do contain some nonradiological constituents that would be hazardous to humans if they entered the groundwater in sufficiently high concentration. Thus, the staff recommends that the monitoring program be expanded to include the determination of nonradiological organic and inorganic constituents.

4.1.1.3 Air quality

Nonradiological air quality has not been monitored at the waste disposal site (Sect. 3.2). However, data cited in Sect. 3.2 indicate that Barnwell County is in an air quality attainment area with respect to all criteria air pollutants.

4.1.1.4 Terrestrial biota

No monitoring or surveying to describe the terrestrial biota has been conducted on the Barnwell site. Before its development as a waste disposal facility, the site was utilized primarily for pulpwood production and agriculture (EA, p. 102). Most of the forested area has been cleared for waste disposal. As additional land is needed for waste disposal, most of the remaining forest will be cleared. The offsite terrestrial biota has been extensively studied by the Savannah River Ecology Laboratory and by scientists from Emory University for AGNS (Sect. 3.9.1).

4.1.1.5 Aquatic biota

No monitoring or surveying program of aquatic biota on or off the site has been established. For reasons enumerated in Sect. 4.1.3, the staff feels that such a monitoring or surveying program need not be initiated.

4.1.1.6 Radiological

The only potential impacts considered significant are radiological; because of this the complete monitoring program appears in Sect. 2.3.5 together with other pertinent material on standard operating procedures and measures to minimize radiological exposures.

4.1.2 Existing mitigatory measures

4.1.2.1 Surface water

The EA prepared by Chem-Nuclear describes mitigatory measures currently being taken to protect surface water quality (EA, pp. 47-48, 129-130, and 146-147). Erosion of the trench overburden is controlled by seeding grass within one year after completion and maintaining appropriate slopes in the trench area. Regular inspections are made to detect eroding areas, and repairs are effected promptly. Surface water infiltration is controlled by forming the overburden into a mound and using a layer of soil [at least 1 m (3 ft) deep] and a clay liner [0.6 m (2 ft) deep] over the wastes.

Water draining off the caps is collected in ditches and directed to a holding basin in the western section of the site for evaporation. If the water level in the basin reaches a certain predetermined level, the contents are pumped to another evaporation pond in the southeast corner of the site. During pumping, the water is sampled at 2-h intervals to assay for radionuclide contamination.

4.1.2.2 Groundwater

Chem-Nuclear monitoring wells are currently being sampled by their own environmental monitoring department. If groundwater samples indicate the presence of radionuclide migration, Chem-Nuclear states that "immediate measures would be undertaken to alleviate the problem and preclude its recurrence."

4.1.2.3 Air quality

The major sources of nonradiological air pollutants are described in Sect. 4.2.1. Fugitive dust is emitted by trucks traveling on unpaved roads, by excavation of disposal trenches, and by daily trench backfilling operations (EA, p. 132). Emission of fugitive dust by site operation is minimized by moistening the road, immediate walk areas and the soil before it is used to cover trenches (EA, p. 132).

4.1.2.4 Terrestrial biota

Because the terrestrial biota on the site has been or will be destroyed, it is not possible to mitigate these impacts. Many of the site operating procedures are designed to reduce impacts to offsite biota. These procedures (EA, Ch. 3) are summarized and evaluated in Sect. 2.3 of this document.

4.1.2.5 Aquatic biota

See Sect. 4.1.3.5.

4.1.2.6 Radiological

See Sects. 2.3.6 and 2.3.7.

4.1.3 Staff-recommended changes

4.1.3.1 Surface water

Surface water does not currently leave the site. The staff has no further recommendations.

4.1.3.2 Groundwater

The staff is of the opinion that the boundary wells located on the perimeter of the site will detect any offsite radionuclide migration. In the event that radionuclide migration is detected this would enable

Chem-Nuclear or the future custodian to initiate mitigating measures to stop such offsite radionuclide migration.

The staff notes that in the past, according to a recent publication, water has apparently accumulated in a few of the trenches and has caused the migration of certain radionuclides up to a vertical depth of 2 m (6 ft) below the trench bottom.[2] Although the migration of these radionuclides has not created a significant impact, the reasons for water accumulating in the trenches are being investigated further, and a report on the probable cause has been sent to the DHEC for further examination. Perhaps the observation sumps located in the trenches should be monitored more frequently after periods of heavy rainfall.

4.1.3.3 Air quality

Available data on ambient air quality[3] and staff observation of the site suggest that continued operation of the Barnwell facility will have no appreciable effects on the air quality of the region. It is the staff's opinion that it is not necessary for the operator to conduct either onsite or offsite nonradiological air-quality monitoring.

4.1.3.4 Terrestrial biota

DHEC currently requires monitoring of onsite and offsite biota. The staff has no further recommendations.

4.1.3.5 Aquatic biota

Because of the distance of streams located from the Barnwell site and the unlikely potential for their contamination from burial activities, the staff suggests that Chem-Nuclear not be required to initiate a monitoring or surveying program for offsite aquatic biota.

As mentioned previously (Sect. 3.6.1), the Carolina bays located on the site do not contain water for long enough periods to be considered aquatic habitats. In addition, the larger Carolina bay is currently being backfilled. Therefore, the staff recommends that no onsite monitoring or surveying program be established.

4.1.3.6 Radiological

See Sects. 2.3.5, 2.3.6, and 2.3.7.

4.2 DIRECT EFFECTS AND THEIR SIGNIFICANCE

4.2.1 Impacts on air quality

Fugitive dust and gaseous pollutants are the principal types of nonradiological atmospheric emissions that result from the operation of the waste disposal facility. Fugitive dust is emitted by trucks traveling on unpaved roads, by excavation of disposal trenches, and by daily trench backfilling operations (EA, p. 132). Combustion of gasoline or diesel fuel in trucks and other types of equipment is a potential source of gaseous pollutants. Although Chem-Nuclear monitors the release of radiological emissions — isotopic gamma, gross beta and gross alpha, and ^{131}I radiation (EA, Tables 8.2 and 8.3) — they do not measure nonradiological particulate and gaseous pollutants.

Emission of fugutive dust by site operation is minimized by moistening soil before it is used to cover trenches (EA, p. 132). The staff's observation of site operation (February 12, 1981) indicated that fugitive dust emissions from the waste disposal facility are minor. Combustion emissions from equipment operation onsite and from the approximately 100 trucks per week that bring radioactive waste to the site are relatively low.

Available data on ambient air quality[3] and staff observation of the site (February 12, 1981) suggest that continued operation of the waste disposal facility will have no appreciable effects on the air quality of the region. It is the staff's opinion that operation of the facility should not be altered on the basis of the emissions of nonradiological pollutants to the atmosphere.

4.2.2 Impacts on land use

The basic land-use pattern in the immediate vicinity of the waste disposal facility has been described in several reports (refs. 4 and 5 and EA, p. 4) and in Sect. 3.5.1 of this document. The waste disposal facility has operated since 1971, and the types of land uses in the surrounding area have not changed appreciably. The land surrounding the site is used primarily for other nuclear facilities (SRP and AGNS) and for crop and pulpwood production. These land uses have coexisted in this region during the 10 years of operation of the waste disposal facility. Because no major change in the mode of operation of the disposal facility is anticipated, continued waste disposal on the site is not likely to adversely affect surrounding land uses.

The major onsite land-use impact is the long-term exclusive use of site for shallow land burial of low-level radioactive waste (EA, p. 101). Chem-Nuclear estimates that the facility will reach its disposal capacity by approximately 2005, depending on the volume of waste produced and the development of other low-level waste disposal facilities (EA, p. 45). After disposal capacity is reached, it will probably be several hundred years before the site could be released for unrestricted use. This assumes that stabilization and long-term care activities are continued until the radioactivity has decayed to innocuous levels.[6]

The site, which is approximately 121 ha (300 acres), was utilized primarily for agriculture and pulpwood production before its development as a waste disposal facility (Sect. 3.9.1). Ninety-five hectares (235 acres) of the site have been designated as an exclusion area that will be deeded to the state of South Carolina when the facility is closed (EA, pp. 1 and 3). Approximately 60% of the forests on the 95-ha (235-acre) area have been cleared, of which over 16 ha (40 acres) have been used for waste burial (EA, p. 1). As additional disposal capacity is needed, much of the remaining forest will be cleared to provide space for trench excavation. As a result of these activities, the site will be unavailable for land uses other than waste burial for a long period of time. This is not considered to be a significant impact because the site is small and abundant land is available offsite for crop and pulpwood production or other land uses (Table 3.3, Sect. 3.5).

Historical, archeological, and scenic resources in the vicinity of the disposal site are described in Sect. 3.5.2. None of the 13 historic sites listed are on or adjacent to the disposal site.[7-9] No important archeological or scenic resources have been identified in the vicinity of the disposal facility.[2,5] Dr. Robert L. Stephenson, State Archeologist, has indicated to the staff February 13, 1981, and March 30, 1981) that field surveys are required to determine if important archeological resources exist on or near the site and if they would be affected by continued operation of the facility. Because this assessment is not related to a licensing action, the applicant is not required by law to conduct an archeological survey.

From the available information, it appears that historical, archeological, or scenic resources would not be adversely affected by continued operation of the waste disposal facility.

A potential land-use conflict may exist with the city of Snelling, South Carolina. The southeastern half of the waste disposal site is within the city limits of Snelling.[4] Although the mayor of Snelling, Mr. E. T. Moore, has indicated to Chem-Nuclear (September 29, 1979) that no zoning exists on adjoining areas and that none is expected in the future,[4] zoning should be watched closely by Chem-Nuclear to ensure that land-use conflicts do not develop.

4.2.3 Impacts on surface water and groundwater

4.2.3.1 Surface water

The EA written by Chem-Nuclear states that no runoff from the BLLWDF is released as an effluent (EA, p. 130). Personal observation of the site after a heavy rain appeared to confirm this statement at least for the area where trench excavation and filling is taking place. No obvious gullies, washes, or man-made pathways for water existed to leave the site. The topography of the trench area results in runoff being directed toward collection ponds onsite (both natural and man-made) and into recently excavated depressions where soil was being removed for use in covering completed trenches. Heavy rains may result in some runoff from peripheral areas of the BLLWDF along boundary roads and office and laboratory buildings. However, this runoff is unlikely to contribute to the water flow or silt load of Mary's Creek and Lower Three Runs Creek via surface pathways. Because of the distance of these streams from the property (Sect. 3.6.1) and the gently sloping topography of the area, any runoff is likely to enter the groundwater or evaporate from roadside ditches, etc., before reaching the streams. The major portion of stream flow in the local creeks represents water that has entered stream channels after movement through the soil[10] (i.e. from groundwater seeps). The potential for contamination of the local streams as a result of groundwater contamination is highly unlikely within the time frame of several hundred years as discussed in Sect. 4.2.8.

Site closure and stabilization plans call for elimination of the collection ponds onsite and alteration of the topography so that surface drainage will flow offsite via the east and west boundaries. Although the amount of additional runoff which would occur after heavy rains cannot be predicted, it still seems likely that this runoff would end up in roadside ditches and local depressions from where it would be absorbed or evaporated rather than channeled to nearby surface waters. Furthermore, revegetation of the site will minimize potential erosion, thereby precluding significant increases in silt carried to surface waters in the vicinity.

Surface drainage waters have never been analyzed for nonradiological contaminants; however, radiological contamination of the surface drainage system is reported to have never occurred during several years of active operation (ref. 10 and EA, p. 107). Thus, contamination of surface drainage after site closure is not expected to occur unless the trench caps become seriously eroded. Because completed trenches are covered with a minimum of two feet of clay and three feet of soil and seeded with grass within one year of trench completion, significant erosion problems are not expected.[11]

4.2.3.2 Impacts on groundwater

Potential impacts on groundwater during the remaining expected life (25 years) of site burial operations are expected to be minimal. The design and construction of the trench caps currently being implemented by Chem-Nuclear will reduce greatly the probability of meteoric water infiltrating the trench confines. In the event that meteoric water enters the trench confines, the length of time it remains in contact with buried waste should be minimal because of the high permeability of the backfill material, trench floor, and the French drain and sumps constructed below the trench floor. If water accumulates in the sumps it may be removed by pumping.

Possible short- and long-term impacts resulting from having contaminated meteoric water migrate from the trench bottom to the saturated zone are discussed in Sect. 4.2.8.

4.2.4 Impacts on mineral resources

The construction of the Barnwell facility has not affected the quality or eventual exploitation of any mineral resource.

4.2.5 Impacts on soils

The soil types on the waste disposal site are described in Sect. 3.8. The major soils are sandy in texture, tend to have low levels of available moisture, are susceptible to rapid leaching of plant nutrients, are severely to moderately limited for agricultural production, and have moderate to high potential for woodland productivity.[12] These characteristics, particularly the severe-to-moderate limitation for agricultural production, are important in an overall evaluation of the soil impacts described below.

Site preparation, which involved clearing vegetated areas and preparing previously cultivated land for waste disposal, produced a substrate that was susceptible to erosion by surface water drainage. As with any surface cleared of vegetation, soil loss from erosion probably occurred. However, information is not available to determine the amount of soil lost by this process.

In addition to loss from erosion, soils may be affected in other ways during normal site operation. The removal of topsoil and the excavation of trenches will tend to disrupt the profile differentiation of the soil. Trench backfilling with topsoil and the addition of topsoil and clay to a completed trench will cause additional soil mixing. The result of these processes is a completed trench covered by a soil layer that lacks its original profile differentiation. However, this appears to be a minimal impact because the completed trenches will support plant growth (staff observation of the site, February 12, 1981).

Trenches that have been filled, capped, and contoured are allowed to settle for up to one year before being seeded with grass. Any subsidence during this period is repaired by applying additional overburden material. During the settling period soil erosion from the unstabilized trench undoubtedly occurs. Although no information is available to assess the magnitude of this loss, it is expected to be minimal.

A soil classified as prime farmland covers 8% of the site (Sect. 3.8). This soil, however, has already been disrupted by site preparation and burial activities. Such an impact is not considered to be significant because of the relatively small amount of land involved.

Soils on the Barnwell site have been or are being affected. However, observation of the site by the staff (February 12, 1981) and information on site operation (Sect. 2.2.3.1) suggest that no major erosion processes are occurring on any part of the site. The staff concludes that, although there is some loss of soil by erosion and some disturbance by trench preparation and filling, these impacts appear to be minor and should not preclude the continued operation of the Barnwell facility.

4.2.6 Impacts on biota

4.2.6.1 Aquatic biota

Impacts on aquatic biota resulting from continued operation and eventual site closure and stabilization are expected to be negligible. Surface water nearest the site is the seepage point where Mary's Creek originates, about 0.9 km (0.6 mile) south of the site. Mary's Creek empties into Lower Three Runs Creek (LTRC) about 4.6 km (2.9 miles) from the site. As discussed in Sect. 4.2.3.1, it is very unlikely that surface or groundwater originating from the site would reach the streams. Thus, the possibility that aquatic biota in the streams could be affected by the continued operation of the BLLWDF is extremely low. Even if some surface water originating from the BLLWDF does reach the streams, radionuclides are not expected to be a component of surface runoff because contamination of the surface water drainage system has never occurred during several years of operation (ref. 10 and EA, p. 107). We assume, therefore, that hazardous chemicals, which could be associated with LLW, are also absent from surface drainage waters. Although analyses have never been conducted, license restrictions on the type of waste accepted serve to confirm this. For instance, wastes containing toluene, xylene, dioxane, scintillation liquids, or any other organic compounds with similar properties are not accepted. It is therefore assumed that the possibility of surface runoff containing hazardous chemical waste is very low under normal operating conditions and expected site closure plans. Some silt and clay could be carried by surface runoff during site operation, but the distance to the streams and the low topographical relief would tend to result in deposition of particulates before reaching the streams.

Groundwater transport of contaminants is the major concern at most LLW disposal facilities.[10] As discussed in Sect. 4.2.8, however, groundwater transport through the soils in the Barnwell area is so slow that radionuclides or hazardous chemicals originating from trenches on the site would reach the streams only after hundreds of years at a minimum (see

Sect. 4.2.8). Therefore, sufficient time would be available to implement effective mitigating measures (Sect. 4.1.2) to prevent contact of the groundwater with surface waters should groundwater monitoring (Sect. 4.1.1) indicate movement of potentially hazardous contaminants.

In conclusion, based on our current understanding of the hydrology of the area and current operating procedures, the potential for negative impacts on the biota of Mary's Creek or Lower Three Runs Creek as a result of operation of BLLWDF appears to be extremely low. No Federally or state-protected aquatic species or unique aquatic habitats would be affected by continued operation of the facility because none are known to occur in Mary's Creek or LTRC (Sect. 3.9.2).

4.2.6.2 Terrestrial biota

The primary impact to terrestrial biota from operation of the Barnwell facility results from the removal of vegetation and the associated loss of animal habitat. Sixty percent of the terrestrial vegetation has been removed from the portion of the site that is being used for waste disposal (Sect. 3.9.1). As additional disposal capacity is needed, most of the remaining vegetation will be cleared. The small areas that have not been cleared are primarily planted loblolly pine with occasional inclusions of pine-scrub oak forest and pine-oak forest. Although no longer vegetated, the remnants of a small Carolina bay, which is being back-filled during current site operations, is also present. None of the habitats existing on the site are unusual for the region. They represent major habitat types found in the Barnwell area.[13] Because of their common occurrence in the region and the small land area involved [95 ha (235 acres)], the destruction and loss of these habitats from the site constitutes a minor impact on terrestrial biota (EA, p. 1).

Because the Barnwell facility has been operating for 10 years, it is impossible to assess the impact that initial site preparation, including clearing vegetation, may have had on endangered and threatened species. It is possible to assess the potential impact of continued operation on such species. No Federally protected plant species are known to exist in the Barnwell area. Of eight species under Federal status review, only one, sandalwood (*Nestronia umbellula*) (Table 3.22), may potentially occur on the site. It requires a woodland habitat and is thought to be parasitic on pine tree roots. Habitat required for the other seven species (Table 3.22) does not occur on the site.

Four Federally protected animals, the red-cockaded woodpecker, bald eagle, American alligator, and eastern cougar, may occur in the Barnwell area (Table 3.22). It is unlikely that any of the four species occur on or visit the waste disposal site. The red-cockaded woodpecker requires mature, open pine stands approximately 60 years old for its habitat. No such habitat exists on the waste disposal site. The bald eagle primarily occurs near lakes and rivers, depending mainly on fish for food. Preferred habitat of the American alligator is rivers, lakes, or swamps. The aquatic habitats necessary for these two species do not exist on the site. The eastern cougar primarily feeds on deer, small mammals, and sometimes, domestic livestock.[14] The waste disposal site is fenced and does not contain habitat that would support the prey required by cougars.

The staff concludes that continued operation of the waste disposal facility would have no significant impacts on the terrestrial biota of the surrounding area. The onsite impacts are difficult to assess because the facility has been operating for 10 years. However, these impacts also appear minimal because the 95-ha (235-acre) area, before its development for waste disposal, was primarily managed pine forest and agricultural land, and thousands of hectares of such land exist in the Barnwell area (Table 3.19).

4.2.7 Radiological impacts

Radiological impacts during the period of site operation fall into two general categories: impacts to the public and impacts to site workers (occupational). These impacts are discussed in the following two sections.

4.2.7.1 Impacts to the public

Three significant potential pathways of radiological exposure to offsite residents exist during and following the burial of the low-level waste. These pathways, although of low probability, are through the release of radioactive materials to the air, leaching of radioactive materials to surface water and groundwater, and direct exposure to external gamma radiation.

Atmospheric Releases

The potential for airborne releases is greatly reduced through restrictive shipping stipulations and preventative operational and monitoring programs. During disposal operations onsite, portable air stations are installed adjacent to the operating disposal trench to monitor the immediate air activity. To date, data taken from these samples and site boundary sampling have indicated no long-term or significant levels of airborne activity to offsite environs.

Radioactive materials leached to surface water or groundwater

The primary transport pathway for contaminants from an eastern waste disposal site to man is via the surface or groundwater medium. The results of samples taken at onsite and offsite monitoring stations have shown that no significant increases in activity levels have occurred in the ground or surface water that are attributable to site operations since the operation of the site began.

Direct Exposure to External Gamma Radiation

The environmental TLD network around the outer perimeter of the site provides the statistical information used to calculate the potential exposure to the offsite environment. The TLD statistics at the site boundary have shown that exposures to individuals immediately adjacent to the site would be essentially equal to normal background exposures for that region (106 millirem/year).

In summary, the radiological impacts of the BLLWDF to the general public have been negligible in that no offsite release of radionuclides to the air, surface water, or groundwater pathways attributable to that facility has been detected by monitoring methods. In addition, the dose from external gamma measured at the site boundary does not exceed the background for the area.

4.2.7.2 Occupational impacts

The purpose of this section is to review exposure levels experienced under the existing administrative structure and exposure control mechanisms at the Barnwell facility. Results of external exposure monitoring are discussed first and are followed by a discussion of internal exposure levels.

External Exposure Levels

Annual personnel monitoring reports submitted by the licensee (see Table 4.2(a)) indicate that external radiation exposure levels experienced are below maximum permissible limits set in 10 CFR 20.101. The licensee also submitted data which categorizes exposure levels experienced for each occupational classification. Table 4.2(b) presents exposure data for the years 1978-1980 for the three occupational classifications having the highest exposure histories. Review of the total man-rem/year over this three-year period demonstrates mixed results. However, the average man-rem/yr shows an annual reduction in all three job categories. All remaining occupational groups experienced exposure level at much lower levels.

The external exposure data for 1980 which was provided by the licensee is presented in graphic form at monthly intervals in Figures 4.2 and 4.3. In April 1980, when high activity, low volume shipments began arriving with increasing frequencies, an increase in personnel exposure of off-loaders was noted by the licensee. Specific exposure goals were established by the ALARA Committee for off-loaders and equipment operators in response to this increase. The exposure goals represent a targeted fifty percent reduction in aggregate occupational exposure per month for off-loaders and a thirty-three percent reduction for equipment operators. As shown in Figure 4.2, the licensee made considerable progress toward the ALARA goal for off-loaders during 1980, but less demonstrable progress in the equipment operators'

Table 4.2(a) CNSI employee frequency distribution for whole body exposure ranges, 1978-1979

Exposure Range	Number of CNSI Employees in Each Range	
	1978	1979
Less than 0.010 rem	105	216
0.010 - 0.099 rem	36	105
0.100 - 0.099 rem	8	37
0.250 - 0.499 rem	7	17
0.500 - 0.749 rem	2	3
0.750 - 0.999 rem	5	4
1.000 - 1.999 rem	5	14
2.000 - 2.999 rem	7	14
3.000 - 3.999 rem	10	1
4.000 - 3.999 rem	1	0
5.000 - 5.999 rem	0	0
6.000 - 6.999 rem	0	0
7.000 - 7.999 rem	0	0
8.000 - 8.999 rem	0	0
9.000 - 9.999 rem	0	0
10.000 - 10.999 rem	0	0
11.000 - 11.999 rem	0	0
12.000 or more	0	0

Table 4.2(b) Selected occupational radiation exposures, Barnwell facility, 1978-1980

	1978	1979	1980 (1/80-11/80)
H.P. Techs			
Total Man-Rem	12.0	11.2	11.4
Number of Employees	4	9	14
Man-Rem/Employee	3	1.2	0.8
Offloaders			
Total Man-Rem	23.7	33.5	27.3
Number of Employees	9	16	16
Man-Rem/Employee	2.6	2.1	1.7
Equipment Operators			
Total Man-Rem	16.2	13.8	11.5
Number of Employees	6	7	7
Man-Rem/Employee	2.7	2.0	1.6

SOURCE: Chem-Nuclear Systems, Inc.

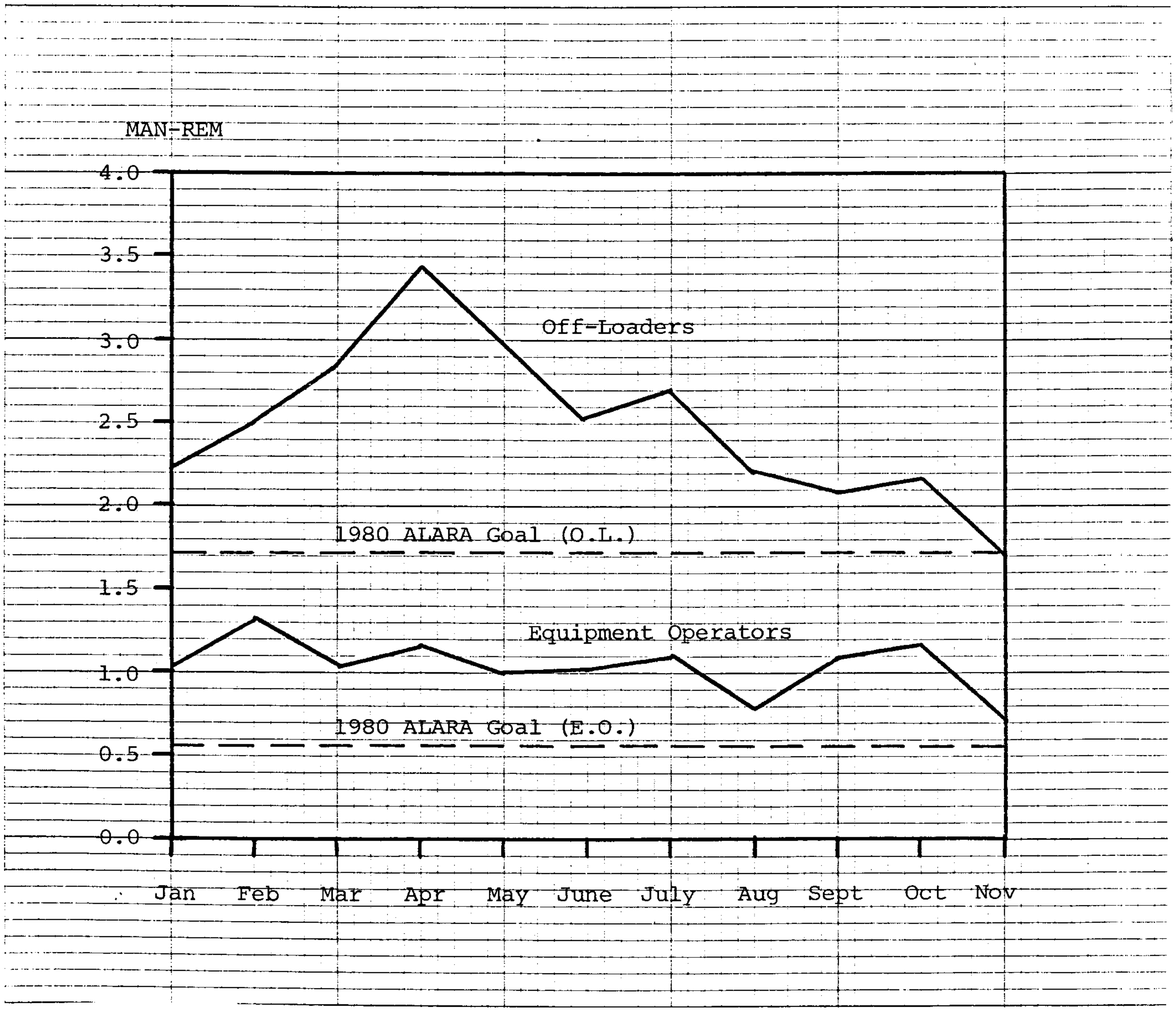
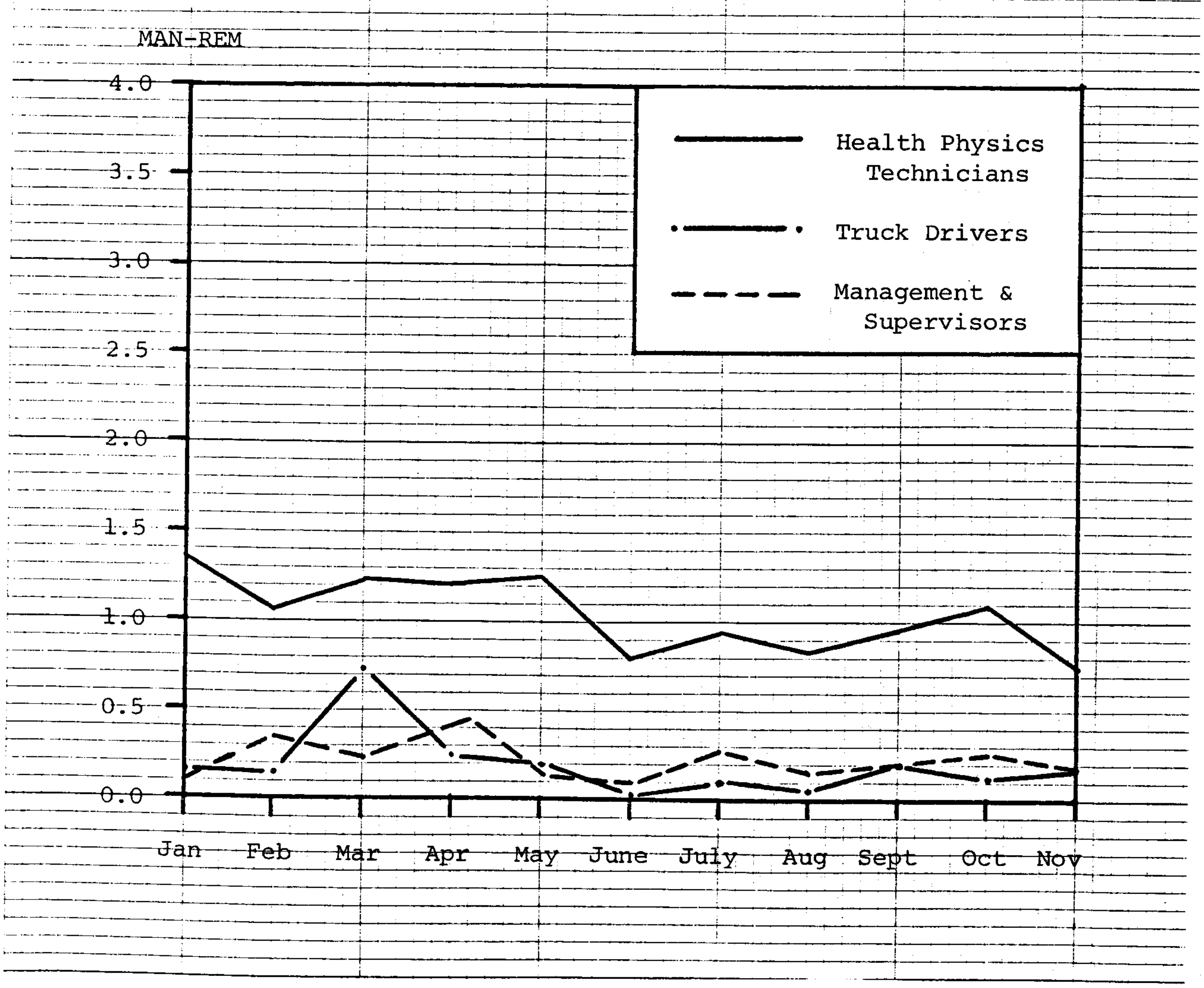


Figure 4.2 1980 monthly exposures and ALARA goals for off-loaders and equipment operators at CNSI's Barnwell facility



(Occupational categories receiving less than 0.1 man-rem/month not shown)

Figure 4.3 1980 monthly exposures for selected occupational categories at CNSI's Barnwell facility category. Health physics technicians (the third highest exposure occupational category) experienced a general decline in exposure level over the year, while all other occupational categories remained constant at aggregate levels of less than 0.4 man-rem per month.

The licensee has shown in the date provided in Tables 4.2(a) and 4.2(b) and Figures 4.2 and 4.3 that exposure levels for occupational personnel personnel are well within maximum permissible limits. Moreover, the licensee has shown a commitment to reduce exposures through improvements.

Internal Exposure Levels

Internal exposure from deposits of radioactivity in the body has generally not been a problem at the Barnwell facility. An NRC inspection in 1978 reported no evidence of personnel uptake of radioactivity from the results of whole body counts done on March 8 and 9, 1978, on 26 employees. The licensee conducts quarterly urinalyses and annual whole body counts to assure that internal exposure is controlled.

4.2.8 Potential impacts after site closure and stabilization

The staff considers the principal pathway for potential offsite releases of radionuclides from the Barnwell site to be the groundwater pathway. The staff therefore reviewed the hydrogeology of the Barnwell site and modeled groundwater flow and transport of radionuclides through the aquifers underlying the site. Modeling was used to predict the potential concentrations and associated doses at a hypothetical well drilled downgradient from the waste disposal area at the site boundary and at natural groundwater discharge areas such as Mary's Branch Spring and Mary's Branch Creek.

The staff performed the modeling studies in two parts. The first of these studies involved modeling groundwater flow in the aquifers underlying the Barnwell site using the U.S. Geological Survey two-dimensional finite-difference model for aquifer simulation.[15] The second part involved modeling transport of radionuclides in the aquifers using a generic model[16] which was developed by Dames and Moore for the Atomic Industrial Forum.

Site Hydrogeology. Review of available literature and data derived from U.S. Geological Survey studies of the hydrogeology of the Barnwell site identified four aquifers (zones) underlying the site. The uppermost aquifer (zone 1) consists of clayey sand with a saturated thickness of approximately 20 to 30 feet in the waste disposal area. Groundwater in the uppermost aquifer occurs under water table conditions and is recharged primarily by the infiltration of precipitation. Low-level radioactive wastes are buried in trenches excavated within generally 8 to 10 feet of the water table. Potential releases of radionuclides would result from dissolution of the radionuclides from the buried waste by that part of the infiltrating precipitation which recharges the water table aquifer. This recharge to the water table aquifer is estimated to be approximately 14 inches of water per year, occurring primarily during a 3 to 4 month winter period. Approximately 90 percent of the recharge to zone 1 discharges by leakance downward to the underlying confined aquifer, zone 2, under a head difference ranging generally between 0 to 6 feet. The remainder of the recharge is lost by evapotranspiration and discharge to surface streams.

The underlying aquifer, zone 2, consists of a more permeable sand unit separated from zone 1 by discontinuous clay lenses or beds. Groundwater occurs under artesian conditions in zone 2 and is recharged primarily by leakance from the overlying zone 1. The effective porosity of zone 2 is approximately 0.40; and, the saturated thickness of zone 2 is on the order of 100 feet. Discharge from zone 2 is primarily to springs and streams, such as Mary's Branch Spring and Mary's Branch Creek. Discharge to the spring has been measured to be 0.4 cubic feet per second; and, based on stream flow measurements, additional discharge to the creek in the modeled area is approximately 0.2 cubic feet per second.

The groundwater modeling studies were restricted to the local groundwater flow system extending from the Barnwell site to Mary's Branch Spring and Mary's Branch Creek. This local flow system involves predominately zones 1 and 2; therefore, zones 3 and 4 were not included in the modeling studies. In order to further simplify the modeling studies, groundwater flow in zone 1 was ignored and the flow of potential releases from the trenches was assumed to be through zone 2 to a hypothetical well located downgradient from the waste disposal area at the site boundary and to natural groundwater discharge areas at Mary's Branch Spring and Mary's Branch Creek. The staff considers this simplifying assumption to be conservative since it neglects the various methods of reduction of concentrations for radionuclides while infiltrating through the 8 to 10 feet thick unsaturated zone under the trenches, flowing in zone 1, and flowing across the clayey units separating the aquifers. The reductions would result from dispersion (advection, dilution, and diffusion), radionuclide decay, retardation (sorption and ion exchange) and precipitation from solution.

Flow Modeling. The groundwater flow modeling was performed first in order to determine necessary site-related inputs to the transport model. For example, the flow modeling identifies approximate values of aquifer coefficients, such as the coefficient of transmissivity, needed to reproduce the known potentiometric surface of the aquifer. In addition, the flow model calculates the Darcy velocity of the groundwater to be used as input into the transport modeling. Likewise, the boundaries of the flow system, the hydraulic gradients, and the length and direction of the shortest flow path are applied from the flow modeling to the transport modeling.

Simply stated, the flow modeling consisted of modeling, in a two-dimensional plan view, the flow in zone 2 by varying hydrogeologic parameters, particularly the coefficient of transmissivity, until the known potentiometric surface for zone 2, as measured in onsite observation wells, was reproduced. No-flow boundaries were used on the periphery of the study area, with the exception of a constant-head boundary representing Mary's Branch Creek and Mary's Branch Spring. For purposes of the modeling study, recharge to zone 2 was held constant throughout the modeled area; with the exception of the waste disposal area where the staff conservatively assumed a recharge of twice the normal recharge. This increased recharge was used to represent a potential increase in infiltration through the trenches as the trench caps are acted upon by natural weathering processes and climatic conditions. A mass-balance was computed to verify that recharge to zone 2 by leakance from zone 1 equaled measured discharge to Mary's Branch Spring and Mary's Branch Creek. The flow modeling closely approximated the known potentiometric surface of zone 2 and the measured flow at Mary's Branch Spring and along Mary's Branch Creek.

Transport Modeling. Using the Dames and Moore model developed for the Atomic Industrial Forum, theoretical doses from potential releases of radionuclides were calculated for a hypothetical well downgradient and across Osborn Road from the waste disposal area and for the natural groundwater discharge to Mary's Branch Spring and Mary's Branch Creek. This model is a generic model employing an analytical solution to determine the transport of radionuclides. Although generic, the model does permit the use of site-related parameters for the aquifer and buried wastes.

In this study, the potential releases were assumed to be generated as leachate during the infiltration of precipitation through an average size trench (approximately 45,000 square feet) located at the edge of the waste disposal area closest to the hypothetical well. The total activity of this average trench was assumed to be three precent (total area of average trench divided by total area of waste disposal) of the total activity as of January 1981. Approximately one percent of the waste in the average trench was assumed to leach per year, primarily during the four-month winter period of recharge to the water-table aquifer.

The hypothetical well was assumed to be downgradient and across Osborn Road on the shortest flow path from the average trench at a distance of 1,300 feet. The hypothetical well was also assumed to be a fully penetrating well completed in zone 2 and pumping at a rate of 100 cubic feet per day. The distance to Mary's Branch Spring and Mary's Branch Creek was taken to be 3,000 feet. The hydraulic conductivity of the unsaturated zone and the saturated zone was assumed to be equal (i.e., the saturated zone was assumed to extend to the trench bottom). The darcy velocity as determined by the flow modeling was on the order of 0.14 to 0.20 feet per day. The dispersivity was conservatively assumed, based on values reported in the literature for a similar aquifer, to be 50 feet; and, the longitudinal dispersion coefficient was calculated, based on dispersivity times Darcy velocity, to be 7 feet squared per day. The ratio of longitudinal dispersion coefficient to transverse dispersion coefficient was assumed to be 5:1.

Ten radionuclides of interest were evaluated. These included strontium-90, cesium-137, cobalt-60, ruthenium-106, tritium, carbon-14, iodine-129, plutonium-239, americium-241, and plutonium-240. The latter four were absent in the January 1981 inventory of total activity. For the six remaining radionuclides, reduction factors in the saturated zone were calculated in part by using ranges of values for retardation coefficients provided in the AIF report for the specific radionuclides. Although calculations were performed over the entire range of values, the staff placed emphasis on the analyses using the lowest values in the ranges of retardation factors.

The AIF model determines the maximum concentration of any radionuclide of interest. It does not calculate the time of occurrence of the maximum concentration. However, the staff anticipates that the maximum concentrations for the individual radionuclides will not coincide due to the variation in retardation coefficients for the individual radionuclides.

The analysis using the AIF model shows that the potential doses due to drinking groundwater contaminated with tritium and the other radionuclides of interest should be well below limits prescribed in 10 CFR Part 20 and the proposed 10 CFR Part 61. The calculated potential dose at the hypothetical well would conservatively be less than 15 mrem/year. The calculated potential dose at Mary's Branch Spring would conservatively be less than 1 mrem/year.

Tritium was shown to be the controlling radionuclide with respect to potential doses at the hypothetical well across Osborn Road or at the natural groundwater discharge areas such as Mary's Branch Spring and Mary's Branch Creek. This determination was anticipated due to the relatively high total activity of tritium in the average trench (in excess of 1000 curies), the relatively long half-life of tritium when compared to the groundwater travel time, and the assumption that there would be no retardation of the tritium.

Migration Modeling. Potential migration of radionuclides in the site groundwater system was also modeled using a two-dimensional, finite-difference method of characteristics model developed by the U.S. Geological Survey.[17] This model was modified by Ertec Western, Inc.[18] to include radionuclide decay and sorption. The model includes site-specific modeling of both groundwater flow and transport.

As in the previous flow modeling, the unit 2 aquifer was modeled in plan view using a network of 211 grid blocks. Each grid block was 250 feet by 250 feet. Area recharge to this aquifer was assumed to be evenly distributed throughout the year at an annual rate of approximately 15 inches of water. In the waste disposal area, an additional 15 inches of water per year were injected by use of imaginary wells, thereby representing the effect of increased infiltration due to potential long-term failure of the trench caps.

Groundwater discharge at Mary's Branch Spring and Mary's Branch Creek was modeled by five imaginary wells, each discharging at equal rates. The total discharge of the wells equaled the sum of the areal recharge and the injected water in the waste disposal area.

Each of the injection wells in the waste disposal area was assigned a concentration equal to one-tenth of one percent of the total activity (as of January 1981) for seven radionuclides of interest. These radionuclides were tritium, carbon-14, cesium-134, cesium-137, cobalt-60, iron-55, and strontium-90. These concentrations were injected throughout the 19 grid blocks in the waste disposal area for 100 years.

The models calculated concentrations throughout the groundwater flow system. Special attention was given to hypothetical wells located downgradient at the existing site boundary and adjacent to Mary's Branch Spring and Mary's Branch Creek. The calculated concentrations of the seven radionuclides were converted to projected doses at these locations by use of dose conversion factors provided in NRC Regulatory Guide 1.109.[19] Assuming intake of approximately 2 liters of water per day, the calculated dose for an adult from ingestion of tritiated water would be less than 10 mrem per year using the hypothetical well at the existing site boundary and less than 4 mrem per year using the hypothetical wells adjacent to Mary's Branch Spring and Mary's Branch Creek. The calculated dose due to ingestion of strontium would be less than 10 mrem per year using the hypothetical well at the existing site boundary. Calculated doses for strontium and tritium do not overlap due to the retardation of strontium. The calculated doses from strontium would be on the order of 5 mrem/year during the peak of the tritium. Tritium would be flushed out of the aquifer during the peak of the strontium.

Calculated doses for strontium at the hypothetical well adjacent to Mary's Branch Spring and Mary's Branch Creek would be negligible. Calculated doses for the other five radionuclides (carbon-14, cesium-134, cesium-137, cobalt-160, and iron-55) would be negligible at either location.

4.3 INDIRECT IMPACTS AND THEIR SIGNIFICANCE

4.3.1 Socioeconomic effects

4.3.1.1 Employment

According to Chem-Nuclear (Charles Towsley, Southeast Personnel Manager, Chem-Nuclear Systems, Inc., February 12, 1981), as of February 1981, the disposal facility has 199 onsite or "direct" employees: 162 hourly and 37 salaried employees. The staff estimates that approximately 120 additional "indirect" or secondary jobs have been induced by facility operations (see Appendix C for the assumptions utilized to calculate employment impacts). These secondary jobs were generated via the multiplier effects caused by incremental increases in expenditures in the local economies by Chem-Nuclear (for equipment and supplies) and by their onsite employees.

Therefore, as of February 1981, it is estimated that approximately 320 local employment opportunities have been generated by the disposal facility (see Table 4.3) Based on the sizes of the labor forces in the region, unemployment statistics, industrial employment patterns, and Chem-Nuclear hiring practices (Towsley communication), the staff has concluded that approximately 260 to 285 of the 320 facility-induced openings have been filled by workers residing in the four-county labor market area. This is, only about an estimated 35 to 60 of the jobs were filled by hiring nonlocal workers.

Table 4.3. Estimated current (1981) incremental impacts on employment, population, and housing[a]

	Total regional impacts		Barnwell		Aiken	
	Low estimate	High estimate	Low estimate	High estimate	Low estimate	High estimate
Local, project-induced employment opportunities	320[b]					
Population influx	110	190	81–141	106–182	4–8	29–49
Families	30	50	22–37	29–48	1–2	8–13
School-age children	25	50	19–37	24–48	1–2	7–13
Housing demands	35	60	27–47	34–58	1–2	8–13

[a]Estimates based on Chem-Nuclear's employment as of February 1981 and staff-derived assumptions (see Appendix C).

[b]Only one employment opportunity estimate was calculated. This employment estimate includes direct or basic jobs plus induced or secondary jobs.

4.3.1.2 Population

Assuming* that (1) all of the nonlocal, facility-induced workers in-migrated into the region (that is, assuming that all of the nonlocal employees moved from outside to inside the four-county region to accept local jobs) and (2) none of the direct and secondary workers are from the same family, the staff estimates that the total facility-generated, in-region population influx (as of February 1981) has been approximately 110 to 190. Based on (1) information supplied by Chem-Nuclear (Charles Towsley, Southeast Personnel Manager, Chem-Nuclear Systems, Inc., February 12, 1981) and (2) analyses of local community infrastructures and their proximities to the site,[20] the staff has concluded that the vast majority of in-migrating workers have probably settled either within or in close proximity to the city of Barnwell, with a small percentage choosing to reside in the Aiken area. The staff estimates that anywhere from 74 to 96% of the facility-induced population increase has occurred in the Barnwell area (81 to 182 persons; see Table 4.3). According to the recent decennial census tabulation, the 1980 population was 5572 for Barnwell city and 8340 for the Barnwell County Census Division (CCD). Therefore, operation of the Chem-Nuclear facility has

*Additional assumptions that were utilized are outlined in Appendix C.

increased the Barnwell population by only a very small fraction. Because the Aiken area is more heavily populated than the Barnwell area (see Sect. 3.4.1), the facility's impact on Aiken's population has been negligible.

4.3.1.3 Housing

The staff estimates (see Table 4.3) that (1) 35 to 60 housing units were needed to accommodate in-migrating employees and their families, (2) most of the housing damand (77 to 97%) was satisfied by settling in the Barnwell area, and (3) most of the demand (30 to 50 units) was for owner-occupied single-family units. Based on past and current housing stocks, housing prices, and vacancy rates (see Sect. 3.4.2 and ref. 21), most incoming workers probably experienced little difficulty in obtaining adequate, affordable housing.

4.3.1.4 School enrollment

The staff estimates that 25 to 50 additional students have enrolled in local school systems as a result of operation of the disposal facility (see Table 4.3). Most of these (19 to 48) have probably enrolled in the Barnwell public school system. The staff did not estimate the number of additional teachers and classroom space that may have been required to accommodate the additional students because (1) it is difficult to estimate the age and school distribution of incoming students and (2) school systems have several options and combinations of options to handle enrollment increases. However, the estimated facility-induced enrollment increases are a very small fraction of total enrollments (the total 1980-1981 school year enrollment for the Barnwell school district was about 2700; see Sect. 3.4.4.4); therefore, the staff is of the opinion that the Barnwell facility has minimally impacted local school systems.

4.3.1.5 Personal income

The staff estimates — based on <u>no</u> changes in the facility's February 1981 employment level — that operation of the Barnwell site will generate approximately $5.5 to $9.1 million in personal incomes during 1981 within the four-county region.* If Chem-Nuclear continues to add employees or if employment declines, then facility-induced personal incomes will either rise or decline accordingly. As a rough gauge, the staff estimates that each dollar change in payroll will cause, through

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*The additional incomes from (1) incremental markups induced by increased commodity demands, (2) local expenditures for project-related supplies, and (3) interest charges for credit purchases were <u>not</u> included in the income estimates.

the multiplier effect, a two- to three-dollar change in local personal incomes. For comparative purposes, the total personal income for Barnwell, Aiken, Allendale, and Bamberg counties was $949.3 million in 1978.[22]

4.3.1.6 Public sector finances

Based on (1) current tax rates and (2) current Chem-Nuclear employment levels and excluding the corporate income, business, and property taxes paid by Chem-Nuclear (that is, accounting for only the taxes paid by Chem-Nuclear employees and/or by facility-induced secondary workers), the staff estimates that Chem-Nuclear employees will pay a total of approximately $88,000 in personal income taxes in 1981 and that all facility-related workers (direct plus secondary) will generate anywhere from $109,000 to $254,000 in sales taxes.*

Although the affected communities, especially Barnwell, may have had to spend some additional funds to handle site-related increases in demand for publicly financed services, the staff has concluded that facility-generated public revenues should have been — and should continue to be — sufficient to cover additional facility-induced costs. This conclusion was based on several factors:

1. Most of the Chem-Nuclear work force requirements have been satisfied by hiring locally. Additionally, based on past and current employment trends (see Sect. 3.4.3) and barring any significant changes in these trends, it appears that the vast majority of future work force additions can be satisfied by hiring locally. Therefore, worker in-migration has been and should continue to be minimal.

2. The affected communities, primarily Barnwell, are large — relative to estimated facility-generated population increases — and are well established. That is, community-supplied services, such as water and sewage, are reasonably up to date (see Sect. 3.4.4.4) and are sufficiently sized to handle facility-related service demands.

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*Employee-related property tax revenues were estimated; but, in the opinion of the staff, these estimates are unreliable. Property taxes paid by facility-induced employees (both direct and secondary) are almost impossible to determine because of the difficulties encountered in accurately quantifying the induced changes in property values, purchases, and utilization. The staff was unable to determine the property taxes directly paid by Chem-Nuclear to local governments in recent years.

4.3.1.7 Public services and facilities

Water and sewage

Based on the estimated facility-induced population increases (81 to 182 persons) and current water usage statistics (see Sect. 3.4.4.4), the staff estimates that, as an upper limit, the demand on Barnwell's water system has increased approximately 1.5×10^5 L/d to 3.4×10^5 L/d (3.9×10^4 gpd to 8.8×10^4 gpd) as a result of operation of the disposal facility. This increase in demand is minimal and is only a small fraction of total system demand [$\sim 12.9 \times 10^6$ L/d (3.4×10^6 gpd); see Sect. 3.4.4.4]. The increased demand on the Aiken water system is also minimal, at most 9.5×10^4 L/d (2.5×10^4 gpd). Local sewage and solid waste disposal systems are also adequate to process the additional facility-related demand increases (see Sect. 3.4.4.4 for a description of local sewage and solid waste systems).

Health and public safety services

Currently, there are approximately (1) one physician for every 1100 persons, (2) a hospital bed for every 90 persons, (3) one policeman for every 510 persons, and (4) one fireman for every 215 persons in the Barnwell city area. Because the disposal facility has caused very little in-migration into the Barnwell area ($\sim$80 to 180 persons), the staff conservatively estimates that, as an upper limit, Barnwell may have had to provide two additional hospital beds and one fireman because of the Chem-Nuclear operation. These impacts are minimal.

Recreation

Because of (1) the diversity and current adequacy of recreation-related facilities within reasonable commuting distance of the project site (see Sect. 3.4.4.4) and (2) limited site-induced population influx (110 to 190 persons), the staff has concluded that any additional demands indirectly placed on these recreational facilities by operation of the disposal site are easily absorbable and should not have adversely affected either services or the adequacy of these amenities.

4.3.2 Potential effects of accidents

Accidents during the operation of the BLLWDF will be minimized through (1) the proper design, construction, and operation of the trenches; (2) adherence to various Federal and State regulations and Chem-Nuclear procedures for LLW transportation and disposal, radiation safety protection, and training; (3) incorporation of a quality assurance program designed to establish and maintain safe operation; and (4) advanced weather warning services to allow time to take necessary corrective action.

In addition, the applicant discharges no liquids to the environment and uses no chemicals in its operations that could result in an accident. Potential accidents associated with site operations that could disperse radioactive materials into the open environment have been considered and include spillage of contaminated material on the ground or equipment at the site and potential releases related to the natural phenomena that are considered possible in the Barnwell area. Each potential accident type is discussed as follows.

4.3.2.1 Spillage

"The potential for spillage of radioactive materials is greatest during off-loading operations near disposal trenches within the exclusion area. Crane linkages are specially designed to retard droppage during removal of waste containers from a cask or from a vehicle. The greatest potential of spillage exists during the stage of off-loading, when containers are released onto others already within the trenches. All containers are released so that the initial impact force is minimized, impact force, consequently, spillage within the trenches has not been a significant operational problem" (EA, p. 134).

"Should spillage occur while containers are still aboard the transport vehicle, the contaminated materials will be immediately cleaned.... The cleaning of spillage in trucks is facilitated by the placing of plywood subfloors in most transports before loadings occur. Any truck found to be contaminated as a result of a spill or normal occurrences will be cleaned at least one tenth of the DOT standards before leaving the site" (EA, p. 134).

4.3.2.2 Earthquakes and floods

The chance of a major earthquake or flood near the Barnwell facility is improbable.

The chance of a major earthquake occurring near the site is small. The last earthquake of a sizable intensity happened in 1886, near Charleston, South Carolina. The site is located in a moderate seismic damage zone. Seismically induced failure of the trenches is unlikely: they should withstand moderate displacements. Any damage incurred would most likely involve cracking of clay seals over trenches and slight to moderate land displacement near the site (see Sect. 3.7.3).

The elevation of the facility makes flooding of the tract by local streams impossible. Details of the surface hydrology of the site area are presented in Sect. 3.6.1.

4.3.2.3 Tornadoes and windstorms

The possibility of the occurrence of a severe windstorm in the immediate area of the site is negligible. The probability of a tornado at a single point in the area of the Barnwell facility is estimated to be less than 10^{-5} per year (EA, Sect. 2.14). Specific data on the history and observed frequency of tornadoes and hurricanes in South Carolina are presented in Sect. 3.1.4.

A relatively severe tornado rated on the Fujita scale as an F-5 "Incredible damages" can exhibit near ground windspeeds of about 402 km/h (250 mph). A completed trench is constructed to withstand such intense windspeeds, either from tornadoes or hurricanes. The buried materials are protected by a cover of overburden, typically 1.5 to 4.3 m (5 to 14 ft) thick. This overburden consists of at least 1 m (3 ft) of topsoil and 0.6 m (2 ft) of compacted clay. The trench is graded to match the contours of the natural terrain and is seeded with grass to control erosion. These characteristics ensure the buried materials will not be disturbed by a tornado or hurricane passing over the surface of a completed trench.[23]

The Barnwell facility has established sufficient radio communications with the state of South Carolina and local law enforcement for National Weather Warning in case of severe weather. In the event that tornado and/or hurricane watch is issued by the National Weather Service, immediate backfilling and other required trench stabilization are conducted to prevent any storm action that might result in removal of packaged wastes from an operating trench. The extent of damage to be expected from a natural windstorm is difficult to predict. Conditions such as wind speed, wind direction, amounts of moisture in the soil, and amount of advance warning dictate the extent of overall damage.

4.3.2.4 Fires and explosions

No potential fire hazard or danger of explosive dispersal of radioactive waste is apparent.

4.3.3 Lack of resource development

If the burial of LLW is restricted or discontinued at this site, other disposal sites would need to be created, which could yield environmental impacts significantly greater than those occurring at the site now.

4.3.4 Possible conflicts between the proposed action and the objectives of Federal, regional, state, and local plans and policies

At this time the staff is not aware of any conflict between the proposed action and the objectives of Federal, regional, state (South Carolina), or local (surrounding communities) plans, policies, or controls for the action proposed as long as proper agencies are contacted, proper applications are submitted, and proper monitoring and mitigatory measures are taken to protect the environment and public health and safety.

4.3.5 Effects on urban quality, historical and cultural resources, and society

Continued operations at the site are not expected to affect urban quality or historical or cultural resources. The short-term societal effects as well as effects after decommissioning and final site stabilization should be minimal.

4.3.6 Effects of funding arrangements on the site operator, state, waste generator, and general public

The effects of the funding arrangements that were discussed in Sect. 2.4.2 are considered with respect to the site operator (Chem-Nuclear), the state of South Carolina, the waste generator, and the general public.

The funding arrangement for the final site stabilization, closure, and decommissioning plan has already taken place. The effect this funding arrangement had on Chem-Nuclear was mainly administrative. The money generated to meet this funding requirement was generated by Chem-Nuclear by implementing a surcharge for each 0.028 m^3 (1 ft^3) of radioactive waste buried at the site, which was passed on to the waste generator. Therefore those waste generators that used the site while this surcharge was in effect bore the entire costs for site stabilization, closure, and decommissioning. During the period from the time burial operations commenced in 1971 to March 24, 1981, the state of South Carolina assumed a disproportionate share of the financial risk, although at a decreasing rate, in the event that the site should happen to close prematurely. Now that there is reasonable assurance that sufficient funds are available for implementation of the proposed final site stabilization, closure, and decommissioning, the general public will benefit because proper site stabilization, closure, and decommissioning will be carried out and thus aid in prohibiting the offsite migration of radionuclides in both the short and long term.

The funding arrangement for the post-long-term maintenance and environmental monitoring program is currently being implemented. The effect of this funding arrangement on Chem-Nuclear is mainly administrative. The money generated to meet this funding requirement is generated by Chem-Nuclear implementing a surcharge for each 0.028 m^3 (1 ft^3) of radioactive waste buried at the site, which is passed on to the waste generator. The state of South Carolina is presently assuming a disproportionate share of the financial risk in the event the site should happen to close prematurely. In an effort to reduce the financial risk presently being borne by the state, a surcharge of \$1.00 per 0.028 m^3 (1 ft^3) of radioactive waste is being passed on to those waste generators currently using the site. This means that those waste generators currently using the site during the implementation of the \$1.00 surcharge are paying a disproportionate share of the costs (in constant dollars) relative to those waste generators using the site in the past and perhaps the future (see Sect. 2.4.2). As long as the site does not close prematurely, the general public should benefit greatly from this funding requirement. Funds generated from this financial requirement will be used to aid in containing and preventing the offsite migration of radionuclides buried at the site at least 100 years.

4.4 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

The total amount of energy used during operations at the Barnwell site is miniscule in relation to the total amount of electrical energy generated by the nuclear industry. The staff is not aware of any direct or indirect conservation potential for the project.

4.5 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

4.5.1 Air quality

The continued operation of the Barnwell facility may result in some increase in the levels of fugitive dust and nonradiological gaseous air pollutants released into the atmosphere (Sect. 4.2.1). However, these increases will be minor and will affect only the immediate vicinity of the site.

4.5.2 Land use

The major adverse land-use impact from continued operation of the facility is the long-term exclusive use of the site for ground burial of LLW (Sect. 4.2.2). Following site closure, estimated to occur in 2005, the site is expected to have to be maintained and monitored until the radioactivity has decayed to innocuous levels. Several hundred years will elapse before the site can be released for other land uses.

4.5.3 Water

Adverse environmental impacts on surface waters are expected to be negligible unless significant groundwater contamination occurs and is discharged to surface waters (see Sect. 4.2.3.1).

4.5.4 Mineral resources

No unavoidable adverse environmental impacts on mineral resources will occur as the result of continued site operations.

4.5.5 Soils

A small area (8%) of the site contains soil that has been classified as prime farmland. This soil has been disturbed by site preparation, trench excavation, and waste burial. The other soils on the site have experienced some erosion and profile disruption as a result of these same processes (Sect. 4.2.5).

4.5.6 Ecological

4.5.6.1 Aquatic biota

Adverse environmental impacts on aquatic biota are expected to be negligible unless significant groundwater contamination occurs and is discharged to surface waters (see Sect. 4.2.8).

4.5.6.2 Terrestrial biota

The primary adverse impact on terrestrial biota is the destruction of natural and planted vegetation during site preparation and operation. All of the vegetation of the 95-ha (235-acre) area used for waste burial will ultimately be destroyed. This will result in the loss of small areas of planted pines, pine-scrub oak forest, and pine-oak forest and a small Carolina bay. Loss of these plant communities represents a potential loss of habitat for terrestrial animals (Sect. 4.2.6.2).

4.5.7 Radiological

Unavoidable radiation exposures have been shown to occur to occupational workers during the handling and transportation of the radioactive waste and to a small segment of the population during the transportation (see Sect. 4.2.7). Thus far, no adverse offsite exposure to the regional population is attributable to the facility operation. Onsite levels of radiation emissions (external gamma) have elevated the background levels only slightly; however, the potential exists for adverse effects to burrowing animals that might penetrate to the depths of the stored materials.

Although abnormal occurrences are not expected, the possibility of such events cannot be eliminated and represent possible unavoidable adverse effects. The most probable adverse effects could be expected to be from localized contamination and radiation exposures from transportation accidents (see Sect. 4.3.2).

Over the long-term existence of the Barnwell facility, the possiblity exists for the leaching of radionuclides from the burial site into the surface water and groundwater, thus presenting a potential for unavoidable adverse impacts. Rigid standards for packaging, handling, and burial of the waste materials and management controls are taken to prevent abnormal occurrences. Finally, the continued management of the waste disposal area represents an unavoidable program of long-term surveillance and care. As shown by the analysis in Sect. 4.2.8, the consequences of leaching pose no threat to public health and safety.

4.6 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

4.6.1 The environment

This section compares the short-term environmental gains and losses of continuing the operation of the BLLWDF and the long-term effects that extend beyond the facility operation and into the infinite future. Short-term effects are generally considered in terms of trade-offs in impact on the environment, land use, and costs. Long-term effects have to do with conservation of energy reserves, environmental effects, and land use.

4.6.1.1 Short-term effects

Gains

The burial of low-level waste material at a central site such as Barnwell enhances its isolation from man's environment. Individual storage of wastes by the many generators of the waste would increase the risks of radiological impacts.

Losses

The natural vegetation of the site has been altered, and its carrying capacity for wildlife will continue to be temporarily reduced. A continuing environmental monitoring program will provide a basis for detecting and assessing impacts that might lead to long-term effects so that timely corrective action can be taken if required.

4.6.1.2 Long-term effects

Gains

Over the long term, the burial of low-level waste at a central location with provisions for care for hundreds of years reduces the risks of environmental impacts. This implies monitoring and maintenance of the area after the operation ceases, in this case by the State of South Carolina.

Losses

The estimated 95 ha (235 acres) used for actual burial of LLW will be taken out of the local agricultural productivity for hundreds of years and will pose a hazard to burrowing-type wildlife for a long period of time. The area may be put to such uses as parking or storage areas or green or park areas for future nuclear plant developments in the vicinity of the burial ground. Short-term disruption of the landscape will not affect long-term aesthetics if proper mitigation measures are taken when disposal procedures are discontinued and facilities removed.

4.6.2 Society

The continued existence of the applicant's operation will have minimal or no effect on the surrounding communities. Any impacts on the surrounding communities from initial construction and the early years of operation of the facility have already occurred. The benefit to society of using this area as an LLW disposal facility appears to far outweigh the minimal environmental perturbation of the area that the facility is currently causing and the inconveniences associated with the long-term restriction of use of the site.

4.7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

4.7.1 Land and mineral resources

Probably several hundred years would pass before the land used for ground burial of LLW could be used for unrestricted use.

Other than the fuel oil and other fuels consumed to generate electrical power utilized in continuing operations at the BLLWDF, no irreversible or irretrievable commitment of mineral resources is anticipated.

4.7.2 Water and air resources

Because of the small volume of groundwater used by operation at the disposal site in comparison to the recharge capacity of the aquifers potentially affected, groundwater use is not considered to represent an irreversible or irretrievable commitment of this resource.

The atmosphere is self-cleaning of pollutants at the low concentrations anticipated and no irreversible or irretrievable commitments of the area's air quality are expected.

4.7.3 Vegetation and wildlife

Although the vegetation and wildlife resources of the site will not be lost indefinitely by continued operation, the site will not return to its former productivity for several hundred years. This loss is insignificant with respect to terrestrial ecological characteristics of the site because, prior to development as a waste disposal facility, the site was used for agriculture and pulpwood production. A small Carolina bay, already greatly altered by operation of the facility, will be irreversibly lost.

4.7.4 Material resources

Irreversible and irretrievable commitments of construction materials, metals, chemicals, and fuels were made during the initial construction of the facility and will continue to be made during operations, decommissioning, and final site stabilization. None of these material resources are in short supply, and all are common to many commercial and industrial operations.

4.8 BENEFIT-COST SUMMARY

4.8.1 General

In general, the need for the disposal of fuel-cycle and non-fuel-cycle wastes is increasing. Wastes from the fuel cycle include those from uranium conversion plants, uranium fuel fabrication plants, and power reactors; those from non-fuel-cycle sources include wastes from hospitals, universities, and industrial concerns. In reactor licensing evaluations the benefits of the energy produced are weighed against related environmental costs, including a prorated share of the environmental costs of the uranium fuel cycle. These incremental impacts in the fuel cycle are justified in terms of the benefits of energy generation. However, it is appropriate to review the specific site-related benefits and costs of an individual fuel-cycle facility such as the Barnwell facility.

4.8.2 Quantifiable economic impacts

Monetary benefits accrue to the community from the presence of the facility, such as local expenditures of operating funds and the state and local taxes paid by Chem-Nuclear. Against these monetary benefits are monetary costs to the communities involved, such as those for new or expanded schools and other community services. It is not possible to arrive at an exact numerical balance between these benefits and costs for any one community unit or for the project because of the ability of the community and possibly the facility to alter the benefits and costs. For example, the community can use various taxing powers to redress any perceived imbalance in favor of the project. The project, on the other hand, may create larger revenues through increased prices to redress any imbalance it suffers through direct or indirect taxation.

4.8.3 The benefit-cost summary

The benefit-cost summary for a fuel-cycle facility such as the Barnwell facility involves comparing the societal benefit of an assured land-filled disposal site against local environmental costs for which there is no directly related compensation. For the project, these uncompensated environmental costs are basically three: groundwater impact, radiological impact, and disturbance of the land. The radiological impacts of the project are small (Sect. 4.6.7). The disturbance of the land is also a small environmental impact. All disturbed land will be reclaimed as the operation continues and after final decommissioning. The analysis performed in Sect. 4.2.8 indicates that no long-term groundwater problems are expected at the site. The benefit that the disposal facility provides is considered to offset the risk of possible groundwater contamination underlying the site.

4.8.4 Staff assessment

The staff concludes that the adverse environmental impacts and socioeconomic costs over the short term are more than offset by the benefit of shallow land burial of LLW at the Barnwell site. The application of the mitigating measures suggested by the applicant, staff, and the other regulatory agencies involved will reduce in both the short and long terms any adverse impacts to acceptable levels.

Finally, in considering the short-term land disturbance, the minimal radiological impact and the societal impacts of the project, and the unlikelihood of significant groundwater contamination underlying the site over the long term, the staff opinion is that the benefits outweigh the costs and burial operation should proceed with due consideration given to the recommendations made by the staff in the summary and conclusions.

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5. PROFESSIONAL QUALIFICATIONS OF THE BARNWELL LLWDF DEIA TASK GROUP

The following individuals were responsible for independent analysis of information provided by the applicant in the EA and in responses to questions subsequently submitted requesting new information or clarification of material in the original EA. This interdisciplinary group obtained information from Federal, state, and local sources to supplement material provided by the applicant and also participated in the scoping process. There are no known relationships between the individuals or the organization that prepared this statement with industries regulated by the NRC and suppliers thereof that might give rise to an apparent or actual conflict of interest regarding the work described in this proposal.

A review of pertinent literature sources was also performed to ensure that potential environmental consequences would be fully assessed and that the final recommendations made by the staff would be in conformance with the state of the art and with the interest of the National Environmental Policy Act.

The qualifications of each individual are listed so that primary responsibility for information in particular sections is apparent. Because much of the Environmental Statement represents joint efforts by the staff, it is impractical to provide a separate listing of contributors to many subsections.

Gorman S. Hill
Health and Safety Research Division
Oak Ridge National Laboratory

Gorman Hill is a research associate in the Technology Assessments Section. Since 1973, he has participated in the radiological assessment of fuel cycle environmental statements and for a series of studies establishing "as low as reasonably achievable" guides for the nuclear fuel cycle. He has been involved in the calculation of radiological dose to man and other biota and in the evaluation of impacts to the maximum exposed individual and to the population. He has worked as a junior chemist, a health physicist, and as a research associate in the field of radiation. Hill assisted in editing material for the International Commission on Radiological Protection Report on Reference Man.

Education:

- Received a B.A. degree in biology from Lincoln Memorial University in 1944
- Received an M.S. degree in zoology with emphasis in radiation biology from the University of Tennessee in 1951

Affiliations:

- Holds membership in the Health Physics Society
- Is a certified health physicist

Minton J. Kelly
Energy Division
Oak Ridge National Laboratory

Minton Kelly is the manager of the Nuclear Fuel Cycle Projects in the Environmental Impacts Section. He coordinates the preparation of Environmental Assessments and Statements, using interdisciplinary groups of specialists chosen by the requirements of each project. His original experience with environmental studies was in 1947–1948 when he supervised the collection of chemical, meteorological, and physical data is estuarine Louisiana as part of a long-range ecological study on oyster mortality. From 1968 through early 1971, he worked with an interdisciplinary team whose responsibilities were to develop methods for assessing the radiological impact of proposed Plowshare projects. With the passage of the National Environmental Policy Act, he became a member of the original team at Oak Ridge National Laboratory developing impact statement methodology. He also supervised the preparation of Nuclear Reactor Environmental Statements until mid 1974. Kelly accepted his present job assignment in August 1977. His other experiences include (1) supervision of instrument integration for the bottom stage of the initial manned moon rocket; (2) electrical and communications design for the Arabian American Oil Company; and (3) development of instrumentation for chemical kinetic studies, radiation resistant insulators, and equipment for studying postulated breeder reactor accidents.

Education:

- Received a B.S. degree in electrical engineering from Texas A&M University in 1947
- Received an M.S. degree in physical chemistry from Texas A&M University in 1961
- Received a Ph.D. degree in physical chemistry from Texas A&M University in 1955

Affiliations:

- Elected a fellow in the American Institute of Chemists
- Holds membership in Sigma Xi

Richard H. Ketelle
Energy Division
Oak Ridge National Laboratory

Richard Ketelle is a member of the Geosciences Group in the Environmental Impact Section. In addition to preparing impact analyses for the geologic soils, and groundwater environments, he is involved in the planning and execution of geologic field sampling and testing programs. Mr. Ketelle has participated in environmental impact assessments for synfuels facilities, development of eastern oil shale, and storage of thermal energy in aquifers. His field activities while at ORNL include supervision of subsurface investigation for a ground-linked heat pump experiment and preparation of a detailed field program to provide data for a groundwater pathway analysis for a low-level radioactive waste disposal site. Before coming to ORNL, Ketelle worked as a consultant to the coal industry planning and supervising coal exploration programs and worked for the U.S. Geological Survey as a field assistant on a mineral resources survey in the Cohutta Wilderness in Georgia. His training is in mineralogy and geochemistry, and he studied heavy metal distribution and mineralogy of suspended stream sediment in streams affected by coal mining as a graduate student.

Education

- Received a B.S. degree in geology from the University of Tennessee in 1973.
- Received an M.S. degree in geology from the University of Tennessee in 1977.

Donald W. Lee
Energy Division
Oak Ridge National Laboratory

Donald Lee is a research associate in the Environmental Impact Section. Since February 1977 he has been involved in the preparation of Environmental Assessments and Environmental Impact Statements for synfuel facilities, nuclear power plants, geothermal power plants, conservation technologies, oil to coal power plant conversions, and nuclear fuel cycle facilities. Additionally, he has provided testimony for the Hudson River Power Case. His previous experiences include (1) product engineer for Ford Motor Company, (2) research assistant and teaching assistant at the University of Michigan, and (3) Instructor at Wayne State University. He is a registered professional engineer in the states of Michigan and Tennessee. His research has focused on fluid dynamics and hydrology in porous media and density-stratified flows as they relate to surface water and groundwater problems.

Education:

- Received a B.S. degree in mechanical engineering from Clarkson College of Technology in 1969.
- Received an M.S. degree in engineering science from Clarkson College of Technology in 1973.
- Received a Ph.D. degree in applied mechanics from the University of Michigan in 1977.

Affiliations:

- Holds associate membership in American Society of Civil Engineers
- Holds associate membership in American Society of Mechanical Engineers
- Holds membership in American Physical Society
- Holds membership in Sigma Xi

Samuel C. Martin
Science Applications, Inc.
Oak Ridge, Tennessee

Samuel Martin is an economist specializing in econometrics, environmental impact assessment, program planning, and power system voltage and loading distribution problems. He has been responsible for the preparation of alternative sections for six uranium milling and mining environmental impact statements. In addition, Martin was responsible for updating the socioeconomic sections of the Programmatic Environmental Impact Statement for the Department of Energy's Strategic Petroleum Reserve Program. His duties have also involved the preparation of guidelines to determine unit operations for the High-Temperature Gas-Cooled Reactor Recycle Facility at Oak Ridge National Laboratory.

Education:

- Received a B.S. degree in electrical engineering from Clemson University in 1967
- Received an M.S. degree in industrial management from Clemson University in 1968
- Received an M.A. degree in economics from the University of Tennessee in 1977

- Is working toward a Ph.D degree in economics from the University of Tennessee

Affiliations:

- Holds membership in the Southern Economic Association, Mid-Continent Regional Science Association, South Carolina Academy of Sciences, and Phi Kappa Phi

- Is a registered engineer-in-training in South Carolina

E. Douglas Waits
Environmental Sciences Division
Oak Ridge National Laboratory

Doug Waits is a professor of biology at Birmingham-Southern College. He is currently on assignment as a terrestrial ecologist in the Environmental Sciences Division of the Environmental Impacts Program at ORNL. His technical specialties are plant community ecology, production ecology, and salt marsh ecology. Waits' environmental assessment experience includes terrestrial ecology studies on the site for a proposed uranium enrichment plant, on the sites for several fossil fuel power plants, and on impacts associated with the reconstruction of a dam and associated hydroelectric plant. At ORNL, he has been studying the environmental impacts associated with the mining and retorting of western and eastern oil shale.

Education:

- Received a B.S. degree in biology from Alabama College in 1962

- Received an M.A. degree in biology from Vanderbilt University in 1964

- Received a Ph.D. degree in botany (plant ecology) from North Carolina State University in 1967

Affiliations:

- Holds membership in the Ecological Society of America, American Association for the Advancement of Science, Sigma Xi, and the Association of Southeastern Biologists

John D. Williams
The BDM Corporation
Oak Ridge, Tennessee

John Williams is a senior engineer and provides technical expertise to the Energy Division of Oak Ridge National Laboratory in the preparation of Environmental assessments and impact statements for the nuclear fuel cycle. His technical training has been in chemical engineering, air and water pollution control, solid waste management, industrial hygiene, and industrial ventilation. Williams' original environmental experience was a study that began in 1968 to collect field samples and analyze water and wastewater samples for the Tennessee Department of Public Health. His first nuclear experience was with the U.S. Atomic Energy Commission, performing accountability inspections for enriched uranium reprocessing plants. As process/project engineer at a nuclear fuel fabrication plant, his responsibilities included managing various production aspects of Type II, III, and advanced nuclear fuel for the Navy's Defense Program and provided technical assistance to ensure both state and Federal regulatory compliance. Williams' specialties are low-level radioactive incineration, process containment and handling of nuclear fuels, hazardous chemical spill prevention, wastewater treatment and disposal, filtration, fluidized bed reactors, and high enriched uranium recovery by liquid-liquid solvent extraction.

Education:

- Received a B.S. degree in chemical engineering from the University of Tennessee in 1972
- Is currently working toward an M.S. degree in environmental health at East Tennessee State University

Affiliations:

- Holds membership in the American Institute of Chemical Engineers and American Nuclear Society
- Is a registered professional environmentalist in the State of Tennessee

Lynn L. Wright
Environmental Sciences Division
Oak Ridge National Laboratory

Lynn Wright is a research associate in the Aquatic Ecology Section. Her technical specialties are population ecology, aquatic invertebrate zoology, and thermal ecology. Since 1974, Wright has been involved in research at ORNL on the effect of thermal effluents from power plants on the population ecology of aquatic invertebrates, such as mayflies and the asiatic clam, *Corbicula*. Her recent work has included the analysis of environmental issues related to small-scale hydroelectric development, particularly dredging and water level fluctuations.

Education:

- Received a B.S. degree in zoology from the University of Washington in 1969

- Received an M.S. degree in zoology from Ohio State University in 1974

Affiliations:

- Holds membership in the Ecological Society of America, the American Fisheries Society, and the North American Benthological Society

Appendix B

REGULATORY AGENCIES

AND

EXCERPTS FROM STATE AND FEDERAL REGULATIONS

Appendix B

REGULATORY AGENCIES AND EXCERPTS FROM STATE AND FEDERAL REGULATIONS

B.1 REGULATORY AGENCIES

South Carolina requirements for the transportation of radioactive waste into or within the state may be found in South Carolina Department of Health and Environmental Control, Regulation 61-83 (Appendix E). In addition, all persons subject to the provisions of this regulation are subject to all applicable provisions of the Department of Transportation's Hazardous Materials Regulations, 49 CFR Parts 171-179, 386-399, the NRC's Packaging of Radioactive Material for Transport and Transportation of Radioactive Material, 10 CFR Part 71 (this Appendix), and Regulation 61-63 of the 1976 Code of Laws of South Carolina.

The transportation of radioactive by-product materials, source materials, and special nuclear materials (SNM) within the United States is regulated by NRC. DOT regulates all radioactive materials in interstate commerce.

The packaging or transportation of certain quantities of radioactive material or waste is subject to the issuance of appropriate certificates of compliance by NRC. Applicants must show both by analysis and by experiment that the proposed packaging and transportation vehicle meets all the requirements set forth in the Federal regulations. Inspection and accountability procedures must also be appropriately designed, as specified in the regulations.

Most states have adopted uniform regulations pertaining to intrastate transportation of radioactive materials, which require the shipper to conform to the packaging, labeling, and marking requirements of DOT to the same extent as if the transportation were subject to the rules and regulations of that agency.[1]

B.2 CLASSIFICATION AND CONTAINMENT

Radioactive wastes are classified for transportation purposes into one of seven transport groups, according to their radiotoxicity and potential hazard if released to the environment. Transport Group I is the most restrictive, and Transport Group VII is the least restrictive.

Each shipment of radioactive materials is classified as Type A, Type B, or large quantity of radioactive materials, depending on the amount of radioactive material it contains. Type A packages may fail in accident situations, but the radiological consequences would be limited because of the limited package contents.[1] When the radioactive content of a package exceeds the small Type A quantity limit, it may be transported only in a Type A or B package depending upon the quality of material involved. Type B packages must be designed to withstand a series of specified impact, puncture, and fire environments, thus providing reasonable assurance that the packaging will withstand most severe transportation accidents.

If a shipment contains materials from more than one transport group, then the most restrictive group will apply for determination of the quantity type. Table B.1 presents a summary of the quantity limits for the seven transport groups.[2]

Table B.1. Quantity limits for the seven transport groups[a]

Transport group	Limited quantity[b] (Ci)	Type A quantity[c] (Ci)	Type B quantity[c] (Ci)
I	$\leqslant 10^{-5}$	10^{-5} to 10^{-3}	10^{-3} to 20
II	$\leqslant 10^{-4}$	10^{-4} to 5×10^{-2}	5×10^{-2} to 20
III	$\leqslant 10^{-3}$	10^{-3} to 3	3 to 200
IV	$\leqslant 10^{-3}$	10^{-3} to 20	20 to 200
V	$\leqslant 10^{-3}$	10^{-3} to 20	20 to 5×10^{3}
VI	$\leqslant 10^{-3}$	10^{-3} to 10^{3}	10^{3} to 5×10^{4}
VII	$\leqslant 25$	25 to 10^{3}	10^{3} to 5×10^{4}

[a]The regulations actually prescribe only the upper limits for limited, Type A, and Type B quantities. Any quantity greater than Type B is defined as a "large quantity" of radioactive material and is not applicable.

[b]49 CFR 173.391.

[c]10 CRF 71.4 and 49 CFR 173.389.

Source: This table is a revision of Table 4.1 in *Environmental Assessment for the Barnwell Low-Level Radioactive Waste Disposal Facility,* Chem-Nuclear Systems, Inc., Compliance Assistance and Technical Services, Columbia, S.C., January 1980.

More detailed reviews of Federal regulations pertaining to the transport of radioactive material are found in refs. 2 and 3 and in this Appendix.

Shipments that pose a negligible risk to the public health may be classified as low specific activity (LSA) material, 10 CFR Part 71.4(g). If the radioactivity is distributed essentially uniformly, with a concentration of not more than 0.1 μCi of Group I material per gram of contents or 5 μCi of Group II material per gram or 300 μCi of Group III or IV material per gram, the waste qualifies as LSA material. Externally contaminated nonradioactive material may be considered as LSA provided that the radioactive contamination averaged over 1 m^2 does not exceed 0.1 $\mu Ci/cm^2$ for Group I radionuclides or 1.0 $\mu Ci/cm^2$ for others. Basically, only strong, tight packaging that will not leak in normal transport is required for the shipment of LSA material. Low specific activity limits are not defined for Transport Groups V, VI, and VII.[2]

Radiation control — the transport index

Requirements for transporting radioactive waste provide for adequate control of the radiation emitted from LLW. This radiation is only partially absorbed by the containment and shielding systems. Some passes through the packaging and exposes freight handlers and others who come into close proximity with the package. To meet the radiation control limits, the shipper must provide the necessary shielding to reduce the radiation level outside the package to within the allowable limits.

All shipments received at the Barnwell site shall comply with contamination control limits as prescribed in 49 CFR Part 173.397. This regulation pertains to removable (nonfixed) radioactive contamination. Table B.2 shows the maximum radiation level for transporting radioactive material for both exclusive-use and non-exclusive-use vehicles.

Table B.2. Radioactive materials maximum radiation limits[a]

Location of reading	Distance (ft)	Maximum limit (millirem/h)
External surface of package		200
	3	10[b]
"Sole" or "Exclusive Use" closed transport vehicle		
External surface		
Package	3	1000
Vehicle		200
	6	10
	c	2

[a]See 49 CFR Part 173.393 (I) and (J).
[b]Transport index may not exceed 10.
[c]Any position of the vehicle occupied by a person.

Source: U.S. Department of Transportation, Research and Special Programs Administration, Materials Transportation Bureau, *A Review of the Department of Transportation Regulations for Transportation of Radioactive Material,* Washington, D.C., revised Summer 1980, Table 5.

All radioactive material transport vehicles exiting the Barnwell site shall comply with contamination control limits specified in Operating License No. 097 issued by DHEC.

The transport index (TI) refers to the number written on a package by the shipper to designate the degree of control to be exercised by the carrier during transportation (49 CFR Part 173.389). Specifically, the TI assigned to a package is the highest radiation dose in millirems per hour at 3 ft (0.91 m) from any accessible external surface of a package.

When more than one package of radioactive material is loaded onto a transport vehicle, a total index for the shipment is obtained by summing the TIs for each individual package. The total TI for packages loaded onto a single transport vehicle may not exceed 50 (49 CFR Part 177.842), except for vehicles consigned for exclusive use.

The TI system, together with tables of separation distances, provides control by the carrier over the radiation exposures to personnel handling the packages or to casually exposed persons in the vicinity of accumulations of packages.

Nuclear criticality

A basic safety requirement for transporting radioactive materials is the prevention of nuclear criticality for fissile materials. These are defined in 10 CFR Part 71.4(e). No plutonium is accepted at Barnwell. Special nuclear material up to 4500 g of uranium-235 may be possessed, stored, and disposed of by burial in the ground at Barnwell.[3]

Chem-Nuclear may receive and bury packaged radioactive waste containing no more than 350 grams of uranium-235 per U.S.N.R.C License 46-13536-01 and South Carolina Radioactive Material License No. 097.

REFERENCES FOR APPENDIX B

1. U.S. Department of Transportation, Research and Special Programs Administration, Materials Transportation Bureau, *A Review of the Department of Transportation Regulations for Transportation of Radioactive Material*, Washington, D.C., revised Summer 1980.

2. *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes*, NUREG-0170, U.S. Nuclear Regulatory Commission, Washington, D.C., December 1977.

3. U.S. Energy Research and Development Administration, *Alternatives for Managing Waste from Reactors and Post-Fission Operations in the LWR Fuel Cycle*, ERDA-76-43, Vol. 5, Appendix E, 1976.

APPENDIX B

EXCERPTS FROM FEDERAL REGULATIONS

B.1 NUCLEAR REGULATORY COMMISSION REGULATIONS

B.1.1 10 CFR Part 71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions

UNITED STATES NUCLEAR REGULATORY COMMISSION

RULES and REGULATIONS

TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

PART 71

PACKAGING OF RADIOACTIVE MATERIAL FOR TRANSPORT AND TRANSPORTATION OF RADIOACTIVE MATERIAL UNDER CERTAIN CONDITIONS *

AUTHORITY: The provisions of this Part 71 issued under secs. 53, 63, 81, 161, 182, 183, 68 Stat. 930, 933, 935, 948, 953, 954, as amended, 42 U.S.C. 2073, 2093, 2111, 2201, 2232, 2233, unless otherwise noted. For the purposes of sec. 223, 68 Stat. 958, as amended; 42 U.S.C. 2273, §§ 71.61—71.63 issued under sec. 1610, 68 Stat. 950, as amended; 42 U.S.C. 2201(o) Secs. 202, 206, Pub. L. 93-438, 88 Stat. 1244, 1246, 42 U.S.C. 5842, 5846

§ 71.1 Purpose.

(a) This part establishes requirements for transportation and for preparation for shipment of licensed material and prescribes procedures and standards for approval by the Nuclear Regulatory Commission of packaging and shipping procedures for fissile material (uranium-233, uranium-235, plutonium-238, plutonium-239, and plutonium-241) and for quantities of licensed materials in excess of type A quantities, as defined in § 71.4(q), and prescribes certain requirements governing such packaging and shipping.

38 FR 10437

(b) The packaging and transport of these materials are also subject to other parts of this chapter and to the regulations of other agencies having jurisdiction over means of transport. The requirements of this part are in addition to, and not in substitution for, other requirements.

§ 71.2 Scope.

The regulations in this part apply to each person authorized by specific license issued by the Commission to receive, possess, use or transfer licensed materials, if he delivers such materials to a carrier for transport or transports such material outside the confines of his plant or other place of use.

37 FR 3985

§ 71.3 Requirement for license.

No licensee subject to the regulations in this part shall (a) deliver any licensed materials to a carrier for transport or (b) transport licensed material except as authorized in a general license or specific license issued by the Commission, or as exempted in this part.

§ 71.4 Definitions.

As used in this part:

(a) "Carrier" means any person engaged in the transportation of passengers or property, as common, contract, or private carrier, or freight forwarder, as those terms are used in the Interstate Commerce Act, as amended, or the U.S. Post Office;

(b) "Close reflection by water" means immediate contact by water of sufficient thickness to reflect a maximum number of neutrons;

(c) "Containment vessel" means the receptacle on which principal reliance is placed to retain the radioactive material during transport;

31 FR 9941

(d) "Fissile classification" means classification of a package or shipment of fissile materials according to the controls needed to provide nuclear cri-

*Amended 37 FR 3985

PART 71 • PACKAGING OF RADIOACTIVE MATERIAL FOR TRANSPORT

ticality safety during transportation as follows.

(1) Fissile Class I: Packages which may be transported in unlimited numbers and in any arrangement, and which require no nuclear criticality safety controls during transportation. For purposes of nuclear criticality safety control, a transportation index is not assigned to Fissile Class I packages. However, the external radiation levels may require a transport index number.

(2) Fissile Class II. Packages which may be transported together in any arrangement but in numbers which do not exceed an aggregate transport index of 50. For purposes of nuclear criticality safety control, individual packages may have a transport index of not less than 0.1 and not more than 10. However, the external radiation levels may require a higher transport index number but not to exceed 10. Such shipments require no nuclear criticality safety control by the shipper during transportation.

(3) Fissile Class III: Shipments of packages which do not meet the requirements of Fissile Classes I or II and which are controlled in transportation by special arrangements between the shipper and the carrier to provide nuclear criticality safety.

33 FR 17621

(e) "Fissile materials" means uranium-233, uranium-235, plutonium-238, plutonium-239, and plutonium-241;

(f) "Large quantity" means a quantity of radioactive material, the aggregate radioactivity of which exceeds any one of the following:

(1) For transport groups as defined in paragraph (p) of this section:

(i) Group I or II radionuclides: 20 curies;

(ii) Group III or IV radionuclides: 200 curies;

(iii) Group V radionuclides: 5,000 curies;

(iv) Group VI or VII radionuclides: 50,000 curies;

and

(2) For special form material as defined in paragraph (o) of this section: 5,000 curies

(g) "Low specific activity material" means any of the following

(1) Uranium or thorium ores and physical or chemical concentrates of those ores,

(2) Unirradiated natural or depleted uranium or unirradiated natural thorium,

(3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 millicuries per milliliter

(4) Material in which the activity is essentially uniformly distributed and in which the estimated average concentration per gram of contents does not exceed.

(i) 0.0001 millicurie of Group I radionuclides, or

(ii) 0.005 millicurie of Group II radionuclides; or

(iii) 0.3 millicurie of Groups III or IV radionuclides.

33 FR 17621

NOTE This includes, but is not limited to, materials of low radioactivity concentration such as residues or solutions from chemical processing; wastes such as building rubble, metal, wood, and fabric scrap, glassware, paper, and cardboard, solid or liquid plant waste, sludges, and ashes.

(5) Objects of nonradioactive material externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination, when averaged over an area of 1 square meter, does not exceed 0.0001 millicurie (220,000 disintegrations per minute) per square centimeter of Group I radionuclides or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter of other radionuclides.

(h) "Maximum normal operating pressure" means the maximum gauge pressure which is expected to develop in the containment vessel under the normal conditions of transport specified in Appendix A of this part;

(i) "Moderator" means a material used to reduce, by scattering collisions and without appreciable capture, the kinetic energy of neutrons;

(j) "Optimum interspersed hydrogenous moderation" means the occurrence of hydrogenous material between containment vessels to such an extent that the maximum nuclear reactivity results;

(k) "Package" means packaging and its radioactive contents;

31 FR 9941

(l) "Packaging" means one or more receptacles and wrappers and their contents excluding fissile material and other radioactive material, but including absorbent material, spacing structures, thermal insulation, radiation shielding, devices for cooling and for absorbing mechanical shock, external fittings, neutron moderators, nonfissile neutron absorbers and other supplementary equipment,

(m) "Primary coolant" means a gas, liquid, or solid, or combination of them, in contact with the radioactive material or, if the material is in special form, in contact with its capsule, and used to remove decay heat;

(n) "Sample package" means a package which is fabricated, packed, and closed to fairly represent the proposed package as it would be presented for transport, simulating the material to be transported, as to weight and physical and chemical form;

31 FR 9941

(o) "Special form" means any of the following physical forms of licensed material of any transport group:

(1) The material is in solid form having no dimension less than 0.5 millimeter or at least one dimension greater than five millimeters; does not melt, sublime, or ignite in air at a temperature of 1,000° F.; will not shatter or crumble if subjected to the percussion test described in Appendix D of this part; and is not dissolved or converted into dispersible form to the extent of more than 0.005 percent by weight by immersion for 1 week in water at 68° F. or in air at 86° F.; or

(2) The material is securely contained in a capsule having no dimension less than 0.5 millimeter or at least one dimension greater than five millimeters, which will retain its contents if subjected to the tests prescribed in Appendix D of this part; and which is constructed of materials which do not melt, sublime, or ignite in air at 1,475° F., and do not dissolve or convert into dispersible form to the extent of more than 0.005 percent by weight by immersion for 1 week in water at 68° F. or in air at 86° F.

(p) "Transport group" means any one of seven groups into which radionuclides is normal form are classified, according to their toxicity and their relative potential hazard in transport, in Appendix C of this part.

(1) Any radionuclide not specifically listed in one of the groups in Appendix C shall be assigned to one of the Groups in accordance with the following table:

33 FR 17621

	Radioactive half-life		
Radionuclide	0 to 1000 days	1000 days to 10^6 years	Over 10^6 years
Atomic number 1-81.	Group III	Group II	Group III.
Atomic number 82 and over.	Group I	Group I	Group III.

(2) For mixtures of radionuclides the following shall apply

(i) If the identity and respective activity of each radionuclide are known, the permissible activity of each radionuclide shall be such that the sum, for all groups present, of the ratio between the total activity for each group to the permissible activity for each group will not be greater than unity.

(ii) If the groups of the radionuclides are known but the amount in each group cannot be reasonably determined, the mixture shall be assigned to the most restrictive group present

(iii) If the identity of all or some of the radionuclides cannot be reasonably determined, each of those unidentified radionuclides shall be considered as belonging to the most restrictive group which cannot be positively excluded.

(iv) Mixtures consisting of a single radioactive decay chain where the radionuclides are in the naturally occurring proportions shall be considered as consisting of a single radionuclide. The group and activity shall be that of the first member present in the chain, except that if a radionuclide "x" has a half-life longer than that of that first member and an activity greater than that of any other member, including the first, at any time during transportation, the transport group of the nuclide "x" and the activity of the mixture shall be the maximum activity of that nuclide "x" during transportation.

Terms defined in Parts 20, 30 to 36 inclusive, and 70 of this chapter have the same meaning when used in this part.

(q) "Type A quantity" and "type B quantity" means a quantity of radioactive material the aggregate radioactivity of which does not exceed that specified in the following table:

Transport groups see § 71.4(p)	Type A quantity (in curies)	Type B quantity (in curies)
I	0.001	20
II	0.05	20
III	3	200
IV	20	200
V	20	5,000
VI and VII	1,000	50,000
Special form	[1] 20	5,000

§ 71.5 Transportation of licensed material.

(a) No licensee shall transport any licensed material outside of the confines of his plant or other place of use, or deliver any licensed material to a carrier for transport, unless the licensee complies with the applicable requirements of the regulations appropriate to the mode of transport, of the Department of Transportation in 49 CFR Parts 170-189, 14 CFR Part 103 and 46 Part 146, and the U.S. Postal Service in 39 CFR Parts 14 and 15 insofar as such regulations relate to the packaging of byproduct, source, or special nuclear material, marking and labeling of the packages, loading and storage of packages, placarding of the transportation vehicle, monitoring requirements and accident reporting

(b) When Department of Transportation regulations are not applicable to shipments of licensed material by rail, highway, or water because the shipment or the transportation of the shipment is not in interstate or foreign commerce, or to shipments of licensed material by air because the shipment is not transported in civil aircraft, the licensee shall conform to the standards and requirements of the Department of Transportation specified in paragraph (a) of this section, to the same extent as if the shipment or transportation were in interstate or foreign commerce or in civil aircraft. Any requests for modifications, waivers, or exemptions from those requirements, and any notifications referred to in those requirements shall be filed with or made to, the Nuclear Regulatory Commission.

(c) Paragraph (a) of this section shall not apply to the transportation of licensed material, or to the delivery of licensed material to a carrier for transport, where such transportation is subject to the regulations of the Department of Transportation or the U.S. Postal Service.

EXEMPTIONS

*§ 71.6 Specific exemptions.

On application of any interested person or on its own initiative, the Commission may grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not endanger life or property or the common defense and security.

*§ 71.7 Exemption for no more than Type A quantities.†

A licensee is exempt from all the requirements of this part to the extent that he delivers to a carrier for transport:

(a) Packages each of which contains no licensed material having a specific activity in excess of 0.002 microcurie/gram; or

(b) Shipments subject to the regulations of the Department of Transportation in 49 CFR parts 170—189, 14 CFR part 103, or 46 CFR part 146 or the U.S. Postal Service in 39 CFR parts 14 and 15 of packages each of which contains no more than a type A quantity of radioactive material, as defined in § 71.4(q), which may include one of the following:

(1) Not more than 15 grams of fissile material; or

(2) Thorium, or uranium containing not more than 0.72 percent by weight of fissile material, or

(3) Uranium compounds, other than metal (e.g., UF_4, UF_6, or uranium oxide in bulk form, not pelleted or fabricated into shapes) or aqueous[1] solutions of uranium, in which the total amount uranium-233 and plutonium present does not exceed 1.0‡ percent by weight of the uranium-235 content, and the total fissile content does not exceed 1.00‡ percent by weight of the total uranium content; or

(4) Homogenous hydrogenous[2] solutions or mixtures containing not more than:

(i) 500 grams of any fissile material, provided the atomic ratio of hydrogen to fissile material is greater than 7,600; or

(ii) 800 grams of uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of other fissile material is not more than 1 percent by weight of the total uranium-235 content; or

(iii) 500 grams of uranium-233 and uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of plutonium is not more than 1 percent by weight of the total uranium-233 and uranium-235 content; or

(5) Less than 350 grams of fissile material: *Provided*, That there is not more than 5 grams of fissile material in any cubic foot within the package.

*§ 71.8 Exemption of physicians.

Physicians, as defined in § 35.3(b) of this chapter, are exempt from the regulations in this part to the extent that they transport licensed material for use in the practice of medicine.

§ 71.9 Exemption for fissile material.

A licensee is exempt from requirements in §§ 71.33, 71.35(b), 71.36(b), 71.37, 71.38, 71.39, and 71.40 to the extent that he delivers to a carrier for transport packages each of which contains one of the following

(a) Not more than 15 grams of fissile material; or

(b) Thorium, or uranium containing not more than 0.72 percent by weight of fissile material; or

(c) Uranium compounds, other than metal (e.g., UF_4, UF_6, or uranium oxide

[1] Except that for californium-252, the limit is 2 Ci.

*Redesignated by 38 FR 10437.

†Amended 38 FR 10437

[1] This applies to light water and does not apply to heavy water

[2] This applies to light hydrogen and does not apply to heavy hydrogen (i.e., deuterium or tritium)

‡ Amended 38 FR 16347.

in bulk form, not pelleted or fabricated into shapes) or aqueous[1] solutions of uranium, in which the total amount of uranium-233 and plutonium present does not exceed 1.0‡ percent by weight of the uranium-235 content, and the total fissile content does not exceed 1.00‡ percent by weight of the total uranium content; or

(d) Homogeneous hydrogenous[2] solutions or mixtures containing not more than:

(1) 500 grams of any fissile material, provided the atomic ratio of hydrogen to fissile material is greater than 7,600; or

(2) 800 grams of uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of other fissile material is not more than 1 percent by weight of the total uranium-235 content; or

(3) 500 grams of uranium-233 and uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of plutonium is not more than 1 percent by weight of the total uranium-233 and uranium-235 content; or

38 FR 10437

(e) Less than 350 grams of fissile material: *Provided*, That there is not more than 5 grams of fissile material in any cubic foot within the package.

§ 71.10 Limited exemption for shipment of type B quantities of radioactive material.

A person delivering a type B quantity of radioactive material, as defined in § 71.4(q), to a carrier for transport in accordance with the provisions of a special permit, which has been issued by the Department of Transportation and is in effect on June 30, 1973, is exempt from the requirements in this part with respect to such shipments. The exemption granted by this section shall terminate on December 31, 1973, or on the date on which the DOT special permit expires, whichever is later, except as to activities described both in the special permit and in an application for a license which the person has, prior to the termination date of the exemption, filed with the Commission. If the person has filed such an application, the exemption granted by this section shall continue until the application has been finally determined by the Commission.

GENERAL LICENSES**

*§ 71.11 **General license for shipment of licensed material.**

31 FR 9941

A general license is hereby issued, to persons holding specific licenses issued pursuant to this chapter, to deliver licensed material to a carrier for transport, without complying with the package standards of Subpart C of this part, when either:

(a) The material is shipped as a Fissile Class III shipment with the following limitations on its contents:

38 FR 10437

(1) No single package contains more than a type A quantity of radioactive material, as defined in § 71.4(q); and

31 FR 9941

(2) The fissile material contents of the shipment do not exceed:

(i) 500 grams of uranium-235; or

(ii) 300 grams total of uranium-233, plutonium-238, plutonium-239, and plutonium-241; or

(iii) Any combination of uranium-233, uranium-235, and plutonium in such quantities that the sum of the ratios of the quantity of each of them to the quantity specified in subdivisions (i) and (ii) of this subparagraph does not exceed unity; or

(iv) 2500 grams of plutonium-238, plutonium-239, and plutonium-241 encapsulated as plutonium-beryllium neutron sources, with no one package containing in excess of 400 grams of plutonium-238, plutonium-239, and plutonium-241; or

(b) The material is shipped as Fissile Class II packages with the following limitations on the contents of each package:

38 FR 10437

(1) No single package contains more than a type A quantity of radioactive material, as defined in § 71.4(q); and

(2) No package contains fissile material in excess of the amounts specified in the following table, and each package is labeled with the corresponding transport index:

Maximum quantity of fissile material in a single package				
U-235 (grams)	U-233 (grams)	Plutonium (grams)	Plutonium as Pu-Be neutron sources (grams)	Corresponding transport index
35-40	27-30	23-25	320-400	10
30-35	24-27	21-23	240-320	8
25-30	21-24	19-21	160-240	6
20-25	18-21	17-19	80-160	4
15-20	15-18	15-17	15-80	2

NOTE Combinations of fissile materials are authorized. For combinations of fissile materials, the transport index is the sum of the individual corresponding transport indexes. The total transport index shall not exceed 10.

39 FR 22131

§ 71.12 General license for shipment in DOT specification containers, in packages approved for use by another person, and in packages approved by a foreign national competent authority.

35 FR 6271

A general license is hereby issued, to persons holding a general or specific license issued pursuant to this chapter, to deliver licensed material to a carrier for transport:

38 FR 10437

(a) In a specification container for fissile material as specified in § 173.396 (b) or (c) or for a type B quantity of radioactive material as specified in § 173.394(b) or § 173.395(b), or for a large quantity of radioactive material as specified in § 173.394(c) or § 173.395(c) of the regulations of the Department of Transportation, 49 CFR part 173; or

39 FR 32129

(b) In a package for which a license, certificate of compliance or other approval has been issued by the Commission's Director of Nuclear Material Safety and Safeguards or the Atomic Energy Commission, provided that:

(1) The person using a package pursuant to the general license provided by this paragraph:

(i) Has a copy of the specific license, certificate of compliance, or other approval authorizing use of the package and all documents referred to in the license, certificate, or other approval, as applicable;

(ii) Complies with the terms and conditions of the license, certificate, or other approval, as applicable, and the applicable requirements of this part; and

(iii) Prior to first use of the package submits in writing to the Director of Nuclear Material Safety and Safeguards or the Atomic Energy Commission, his name and license number, the name and license or certificate number of the person to whom the package approval has been issued, and the package identification number specified in the package approval.

(2) The package approval authorizes use of the package under general license provided in this paragraph.

38 FR 10437

(c) In a package which meets the pertinent requirements in the 1967 regulations of the International Atomic Energy Agency and the use of which has been approved in a foreign national competent

[1] This applies to light water and does not apply to heavy water.

[2] This applies to light hydrogen and does not apply to heavy hydrogen (i.e., deuterium or tritium).

**Added 38 FR 10437

‡Amended 38 FR 16347

*Redesignated 38 FR 10437.

authority certificate which has been revalidated by the Department of Transportation, *Provided* That the person using a package pursuant to the general license provided by this paragraph:

(1) Has and complies with the applicable certificate, the revalidation, and the documents referenced in the certificate relative to the use and maintenance of the packaging, and the actions to be taken prior to shipment; and

(2) Complies with the applicable requirements of this part, and the Department of Transportation regulations in 49 CFR part 173, 14 CFR part 103, and 46 CFR part 146.

§ 71.13 Communications.

All communications concerning the regulations in this part should be addressed to the Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director of Nuclear Material Safety and Safeguards, or may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C. or at 7920 Norfolk Avenue, Bethesda, Maryland.

*§ 71.14 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding on the Commission.

*§ 71.15 Additional requirements.

The Commission may by rule, regulation, or order impose upon any licensee such requirements, in addition to those established in this part, as it deems necessary or appropriate to protect health or to minimize danger to life or property.

***§ 71.16 Amendment of existing licenses.

(a) Licenses issued pursuant to this part and in effect on October 4, 1968, which authorize Fissile Class II packages are hereby amended by increasing the minimum number of units specified for each Fissile Class II package by a factor of 1.25. The new number, shall be rounded up to the first decimal. In addition, the term "radiation units" is changed to "transport index" wherever used in the license.

(b) The reference to § 71.7(b) in licenses issued pursuant to this part prior to March 26, 1972,** is changed to § 71.9(b).

(c) The reference to § 71.9(b) in licenses issued pursuant to this part prior to June 30, 1973, is changed to 71.12(b).

Subpart B—License Applications

§ 71.21 Contents of application.

An application for a specific license under this part may be submitted as an application for a license or license amendment under this chapter and shall include, for each proposed packaging design and method of transport, the following information in addition to any otherwise required:

(a) A package description as required by § 71.22;

(b) A package evaluation as required by § 71.23;

(c) A description of proposed procedural controls as required by § 71.24;

(d) In the case of fissile material, an identification of the proposed fissile class.

§ 71.22 Package description.

The application shall include a description of the proposed package in sufficient detail to identify the package accurately and to provide a sufficient basis for evaluation of the packaging. The description should include:

(a) With respect to the packaging:

(1) Gross weight;

(2) Model number;

(3) Specific materials of construction, weights, dimensions, and fabrication methods of:

(i) Receptacles, identifying the one which is considered to be the containment vessel;

(ii) Materials specifically used as nonfissile neutron absorbers or moderators;

(iii) Internal and external structures supporting or protecting receptacles;

(iv) Valves, sampling ports, lifting devices, and tie-down devices;

(v) Structural and mechanical means for the transfer and dissipation of heat; and

(4) Identification and volumes of any coolants and of receptacles containing coolant.

(b) With respect to the contents of the package:

(1) Identification and maximum radioactivity of radioactive constituents;

(2) Identification and maximum quantities of fissile constituents;

(3) Chemical and physical form;

(4) Extent of reflection, the amount and identity of non-fissile neutron absorbers in the fissile constituents, and the atomic ratio of moderator to fissile constituents;

(5) Maximum weight; and

(6) Maximum amount of decay heat.

§ 71.23 Package evaluation.

The applicant shall:

(a) Demonstrate that the package satisfies the standards specified in Subpart C;

(b) For a Fissile Class II package, ascertain and specify the number of similar packages which may be transported together in accordance with § 71.39; and

(c) For a Fissile Class III shipment, describe any proposed special controls and precautions to be exercised during transport, loading, unloading, and handling, and in the event of accident or delay.

§ 71.24 Procedural controls.

The applicant shall describe the regular and periodic inspection procedures proposed to comply with § 71.51(c).

§ 71.25 Additional information.

The Commission may at any time require further information in order to enable it to determine whether a license, certificate of compliance, or other approval should be granted, denied, modified, suspended, or revoked.

Subpart C—Package Standards

§ 71.31 General standards for all packaging.

(a) Packaging shall be of such materials and construction that there will be no significant chemical, galvanic, or other reaction among the packaging components, or between the packaging components and the package contents.

(b) Packaging shall be equipped with a positive closure which will prevent inadvertent opening.

(c) Lifting devices:

(1) If there is a system of lifting devices which is a structural part of the package, the system shall be capable of supporting three times the weight of the loaded package without generating stress in any material of the packaging in excess of its yield strength.

(2) If there is a system of lifting

*Redesignated by FR 10437
***Amended 37 FR 3985

**Effective date of this amendment

devices which is a structural part only of the lid, the system shall be capable of supporting three times the weight of the lid and any attachments without generating stress in any material of the lid in excess of its yield strength.

(3) If there is a structural part of the package which could be employed to lift the package and which does not comply with subparagraph (1) of this paragraph, the part shall be securely covered or locked during transport in such a manner as to prevent its use for that purpose.

(4) Each lifting device which is a structural part of the package shall be so designed that failure of the device under excessive load would not impair the containment or shielding properties of the package.

(d) Tie-down devices:

(1) If there is a system of tie-down devices which is a structural part of the package, the system shall be capable of withstanding, without generating stress in any material of the package in excess of its yield strength, a static force applied to the center of gravity of the package having a vertical component of two times the weight of the package with its contents, a horizontal component along the direction in which the vehicle travels of 10 times the weight of the package with its contents, and a horizontal component in the transverse direction of 5 times the weight of the package with its contents.

(2) If there is a structural part of the package which could be employed to tie the package down and which does not comply with subparagraph (1) of this paragraph, the part shall be securely covered or locked during transport in such a manner as to prevent its use for that purpose.

(3) Each tie-down device which is a structural part of the package shall be so designed that failure of the device under excessive load would not impair the ability of the package to meet other requirements of this subpart.

§ 71.32 Structural standards for type B and large quantity packaging.

Packaging used to ship a type B or a large quantity of radioactive material as defined in § 71.4 (q) and (f), shall be designed and constructed in accordance with the structural standards of this section.

Standards different from those specified in this section may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment

(a) *Load resistance.* Regarded as a simple beam supported at its ends along any major axis, packaging shall be capable of withstanding a static load, normal to and uniformly distributed along its length, equal to 5 times its fully loaded weight, without generating stress in any material of the packaging in excess of its yield strength.

(b) *External pressure.* Packaging shall be adequate to assure that the containment vessel will suffer no loss of contents if subjected to an external pressure of 25 pounds per square inch gauge.

§ 71.33 Criticality standards for fissile material packages.

(a) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that it would be subcritical if it is assumed that water leaks into the containment vessel, and:

(1) Water moderation of the contents occurs to the most reactive credible extent consistent with the chemical and physical form of the contents; and

(2) The containment vessel is fully reflected on all sides by water.

(b) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that it would be subcritical if it is assumed that any contents of the package which are liquid during normal transport leak out of the containment vessel, and that the fissile material is then:

(1) In the most reactive credible configuration consistent with the chemical and physical form of the material;

(2) Moderated by water outside of the containment vessel to the most reactive credible extent; and

(3) Fully reflected on all sides by water.

(c) The Commission may approve exceptions to the requirements of this section where the containment vessel incorporates special design features which would preclude leakage of liquids in spite of any single packaging error and appropriate measures are taken before each shipment to verify the leak tightness of each containment vessel

§ 71.34 Evaluation of a single package.

(a) The effect of the transport environment on the safety of any single package of radioactive material shall be evaluated as follows:

(1) The ability of a package to withstand conditions likely to occur in normal transport shall be assessed by subjecting a sample package or scale model, by test or other assessment, to the normal conditions of transport as specified in § 71.35; and

(2) The effect on a package of conditions likely to occur in an accident shall be assessed by subjecting a sample package or scale model, by test or other assessment, to the hypothetical accident conditions as specified in § 71.36.

(b) Taking into account controls to be exercised by the shipper, the Commission may permit the shipment to be evaluated together with or without the transporting vehicle, for the purpose of one or more tests.

(c) Normal conditions of transport and hypothetical accident conditions different from those specified in § 71.35 and § 71.36 may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment.

§ 71.35 Standards for normal conditions of transport for a single package.

(a) A package used for the shipment of fissile material or more than a type A quantity of radioactive material, as defined in § 71.4(q), shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in appendix A of this part:

(1) There will be no release of radioactive material from the containment vessel;

(2) The effectiveness of the packaging will not be substantially reduced;

(3) There will be no mixture of gases or vapors in the package which could, through any credible increase of pressure or an explosion, significantly reduce the effectiveness of the package;

(4) Radioactive contamination of the liquid or gaseous primary coolant will not exceed 10^{-7} curies of activity of Group I radionuclides per milliliter, 5×10^{-6} curies of activity of Group II radionuclides per milliliter, 3×10^{-4} curies of activity of Group III and Group IV radionuclides per milliliter; and

(5) There will be no loss of coolant.

(b) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in Appendix A of this part:

(1) The package will be subcritical;

(2) The geometric form of the package contents would not be substantially altered;

(3) There will be no leakage of water into the containment vessel. This requirement need not be met if, in the

evaluation of undamaged packages under § 71.35(a), § 71.39(a)(1), or § 71.40(a), it has been assumed that moderation is present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material, and

(4) There will be no substantial reduction in the effectiveness of the packaging, including:

(i) Reduction by more than 5 percent in the total effective volume of the packaging on which nuclear safety is assessed;

(ii) Reduction by more than 5 percent in the effective spacing on which nuclear safety is assessed, between the center of the containment vessel and the outer surface of the packaging; or

(iii) Occurrence of any aperture in the outer surface of the packaging large enough to permit the entry of a 4-inch cube.

31 FR 9941

(c) A package used for the shipment of more than a type A quantity of radioactive material as defined in § 71.4(q), shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in appendix A of this part, the containment vessel would not be vented directly to the atmosphere.

§ 71.36 Standards for hypothetical accident conditions for a single package.

(a) A package used for the shipment of more than a type A quantity of radioactive material, as defined in § 71.4(q), shall be so designed and constructed and its contents so limited that if subjected to the hypothetical accident conditions specified in appendix B of this part as the free drop, puncture, thermal, and water immersion conditions in the sequence listed in appendix B, it will meet the following conditions:

38 FR 10437

(1) The reduction of shielding would not be sufficient to increase the external radiation dose rate to more than 1,000 millirems per hour at 3 feet from the external surface of the package.

(2) No radioactive material would be released from the package except for gases and contaminated coolant containing total radioactivity exceeding neither:

(i) 0.1 percent of the total radioactivity of the package contents; nor

(ii) 0.01 curie of Group I radionuclides, 0.5 curie of Group II radionuclides, 10 curies of Group III radionuclides, 10 curies of Group IV radionuclides, and 1,000 curies of inert gases irrespective of transport group.

A package need not satisfy the requirements of this paragraph if it contains only low specific activity materials, as defined in § 71.4(g), and is transported on a motor vehicle, railroad car, aircraft, inland water craft, or hold or deck of a seagoing vessel assigned for the sole use of the licensee.

33 FR 17621

(b) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that if subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Puncture, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, the package would be subcritical. In determining whether this standard is satisfied, it shall be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

(3) There is reflection by water on all sides and as close as is consistent with the damaged condition of the package.

§ 71.37 Evaluation of an array of packages of fissile material.

(a) The effect of the transport environment on the nuclear safety of an array of packages of fissile material shall be evaluated by subjecting a sample package or a scale model, by test or other assessment, to the hypothetical accident conditions specified in § 71.38, § 71.39, or § 71.40 for the proposed fissile class, and by assuming that each package in the array is damaged to the same extent as the sample package or scale model. In this case of a Fissile Class III shipment, the Commission may, taking into account controls to be exercised by the shipper, permit the shipment to be evaluated as a whole rather than as individual packages, and either with or without the transporting vehicle, for the purpose of one or more tests.

(b) In determining whether the standards of §§ 71.38(b), 71.39(a)(2), and 71.40(b) are satisfied, it shall be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package, the chemical and physical form of the contents, and controls exercised over the number of packages to be transported together; and

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents.

§ 71.38 Specific standards for a Fissile Class I package.

A Fissile Class I package shall be so designed and constructed and its contents so limited that:

(a) Any number of such undamaged packages would be subcritical in any arrangement, and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging, in which case that greater amount may be considered; and

(b) Two hundred fifty such packages would be subcritical in any arrangement, if each package were subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, with close reflection by water on all sides of the array and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging in which case that greater amount may be considered. The condition of the package shall be assumed to be as described in § 71.37.

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§ 71.39 Specific standards for a Fissile Class II package.

(a) A Fissile Class II package shall be so designed and constructed and its contents so limited, and the number of such packages which may be transported together so limited, that:

(1) Five times that number of such undamaged packages would be subcritical in any arrangement if closely reflected by water; and

(2) Twice that number of such packages would be subcritical in any arrangement if each package were subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, with close reflection by water on all sides of the array and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging, in which case that greater amount may be considered. The condition of the package shall be assumed to be as described in § 71.37.

(b) The transport index for each Fissile Class II package is calculated by dividing the number 50 by the number of

APPENDIX B—HYPOTHETICAL ACCIDENT CONDITIONS

The following hypothetical accident conditions are to be applied sequentially, in the order indicated, to determine their cumulative effect on a package or array of packages.

1. *Free Drop*—A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.

2. *Puncture*—A free drop through a distance of 40 inches striking, in a position for which maximum damage is expected, the top end of a vertical cylindrical mild steel bar mounted on an essentially unyielding horizontal surface. The bar shall be 6 inches in diameter, with the top horizontal and its edge rounded to a radius of not more than one-quarter inch, and of such a length as to cause maximum damage to the package, but not less than 8 inches long. The long axis of the bar shall be perpendicular to the unyielding horizontal surface.

3. *Thermal*—Exposure to a thermal test in which the heat input to the package is not less than that which would result from exposure of the whole package to a radiation environment of 1,475° F. for 30 minutes with an emissivity coefficient of 0.9, assuming the surfaces of the package have an absorption coefficient of 0.8. The package shall not be cooled artificially until 3 hours after the test period unless it can be shown that the temperature on the inside of the package has begun to fall in less than 3 hours.

4. *Water Immersion* (fissile material packages only)—Immersion in water to the extent that all portions of the package to be tested are under at least 3 feet of water for a period of not less than 8 hours.

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APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES

Element*	Radionuclide***	Group
Actinium (89)	Ac 227	I
	Ac 228	I
Americium (96)	Am 241	I
	Am 243	I
Antimony (51)	Sb 122	IV
	Sb 124	III
	Sb 125	III
Argon (18)	Ar-37	VI
	Ar-41	II
	Ar-41 (uncompressed)**	V
Arsenic (33)	As 73	IV
	As 74	IV
	As 76	IV
	As 77	IV
Astatine (85)	At 211	III
Barium (56)	Ba 131	IV
	Ba-133	II
	Ba 140	III
Berkelium (97)	Bk 249	I
Beryllium (4)	Be 7	IV
Bismuth (83)	Bi 206	IV
	Bi 207	III
	Bi 210	II
	Bi 212	III
Bromine (35)	Br 82	IV
Cadmium (48)	Cd 109	IV
	Cd 115 m	III
	Cd 115	IV
Calcium (20)	Ca 45	IV
	Ca 47	IV
Californium (98)	Cf 249	I
	Cf 250	I
	Cf 252	I
Carbon (6)	C 14	IV
Cerium (58)	Ce 141	IV
	Ce 143	IV
	Ce 144	III
Cesium (55)	Cs 131	IV
	Cs 134 m	III
	Cs 134	III
	Cs 135	IV
	Cs 136	IV
	Cs 137	III
Chlorine (17)	Cl 36	III
	Cl 138	IV
Chromium (24)	Cr 51	IV
Cobalt (27)	Co 56	III
	Co 57	IV
	Co 58 m	IV
	Co 58	IV
	Co 60	III
Copper (29)	Cu 64	IV
Curium (96)	Cm 242	I
	Cm 243	I
	Cm 244	I
	Cm 245	I
	Cm 246	I
Dysprosium (66)	Dy 154	III
	Dy 165	IV
	Dy 166	IV
Erbium (68)	Er 169	IV
	Er 171	IV
Europium (63)	Eu 150	III
	Eu 152 m	IV
	Eu 152	III
	Eu 154	II
	Eu 155	IV
Fluorine (9)	F 18	IV
Gadolinium (64)	Gd 153	IV
	Gd 159	IV
Gallium (31)	Ga 67	III
	Ga 72	IV
Germanium (32)	Ge 71	IV
Gold (79)	Au 193	III
	Au 194	III
	Au 195	III

See footnotes at end of table.

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APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES—Continued

Element*	Radionuclide***	Group
	Au 196	IV
	Au 198	IV
	Au 199	IV
Hafnium (72)	Hf 181	IV
Holmium (67)	Ho 166	IV
Hydrogen (1)	H 3 (see tritium)	
Indium (49)	In 113 m	IV
	In 114 m	III
	In 115 m	IV
	In 115	IV
Iodine (53)	I 124	III
	I 125	III
	I 126	III
	I 129	III
	I 131	III
	I 132	IV
	I 133	III
	I 134	IV
	I 135	IV
Iridium (77)	Ir 190	IV
	Ir 192	III
	Ir 194	IV
Iron (26)	Fe 55	IV
	Fe 59	IV
Krypton (36)	Kr 85 m	III
	Kr 85 m (uncompressed).**	V
	Kr 85	III
	Kr 85 (uncompressed).**	VI
	Kr 87	II
	Kr 87 (uncompressed)**	V
Lanthanum (57)	La 140	IV
Lead (82)	Pb 203	IV
	Pb 210	II
	Pb 212	II
Lutecium (71)	Lu 172	III
	Lu 177	IV
Magnesium (12)	Mg 28	III
Manganese (25)	Mn 52	IV
	Mn 54	IV
	Mn 56	IV
Mercury (80)	Hg 197 m	IV
	Mn 56	IV
Mercury (80)	Hg 197 m	IV
	Hg 197	IV
	Hg 203	IV
Mixed fission products MFP		II
Molybdenum (42)	Mo 99	IV
Neodymium (60)	Nd 147	IV
	Nd 149	IV
Neptunium (93)	Np 237	I
	Np 239	I
Nickel (28)	Ni 56	III
	Ni 59	IV
	Ni 63	IV
	Ni 65	IV
Niobium (41)	Nb 93 m	IV
	Nb 95	IV
	Nb 97	IV
Osmium (76)	Os 185	IV
	Os 191 m	IV
	Os 191	IV
	Os 193	IV
Palladium (46)	Pd 103	IV
	Pd 109	IV
Phosphorus (15)	P 32	IV
Platinum (78)	Pt 191	IV
	Pt 193	IV
	Pt 193 m	IV
	Pt 197 m	IV
	Pt 197	IV
Plutonium (94)	Pu 238 (F)	I
	Pu 239 (F)	I

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See footnotes at end of table.

APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES—Continued

Element*	Radionuclides***	Group
	Pu 240	I
	Pu 241 (F)	I
	Pu 242	I
Polonium (84)	Po 210	I
Potassium (19)	K 42	IV
	K 43	III
Praseodymium (59)	Pr 142	IV
	Pr 143	IV
Promethium (61)	Pm 147	IV
	Pm 149	IV
Protactinium (91)	Pa 230	I
	Pa 231	I
	Pa 233	II
Radium (88)	Ra 223	II
	Ra 224	II
	Ra 236	I
	Ra 228	I
Radon (86)	Rn 220	IV
	Rn 222	II
Rhenium (75)	Re 183	IV
	Re 186	IV
	Re 187	IV
	Re 188	IV
	Re Natural	IV
Rhodium (45)	Rh 103 m	IV
	Rh 105	IV
Rubidium (37)	Rb 86	IV
	Rb 87	IV
	Rb Natural	IV
Ruthenium (44)	Ru 97	IV
	Ru 103	IV
	Ru 105	IV
	Ru 106	III
Samarium (62)	Sm 145	III
	Sm 147	III
	Sm 151	IV
	Sm 153	IV
Scandium (21)	Sc 46	III
	Sc 47	IV
	Sc 48	IV
Selenium (34)	Se 75	IV
Silicon (14)	Si 31	IV
Silver (47)(1)	Ag 105	IV
	Ag 110 m	III
	Ag 111	IV
Sodium (11)	Na 22	III
	Na 24	IV
Strontium (38)	Sr 85 m	IV
	Sr 85	IV
	Sr 89	III
	Sr 90	II
	Sr 91	III
	Sr 92	IV
Sulphur (16)	S 35	IV
Tantalum (73)	Ta 182	III
Technetium (43)	Tc 96 m	IV
	Tc 96	IV
	Tc 97 m	IV
	Tc 97	IV
	Tc 99 m	IV
	Tc 99	IV
Tellurium (52)	Te 125 m	IV
	Te 127 m	IV
	Te 127	IV
	Te 129 m	III
	Te 129	IV
	Te 131 m	III
	Te 132	IV
Terbium (65)	Tb 160	III
Thallium (81)	Tl 200	IV
	Tl 201	IV
	Tl 202	IV
	Tl 204	III
Thorium (90)	Th 227	II
	Th 228	I
	Th 230	I
	Th 231	I

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See footnotes at end of table

APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES—Continued

Element*	Radionuclides***	Group
	Th 232	III
	Th 234	II
	Th Natural	III
Thulium (69)	Tm 168	III
	Tm 170	III
	Tm 171	IV
Tin (50)	Sn 113	IV
	Sn 117 m	III
	Sn 121	III
	Sn 125	IV
Tritium (1)	H 3	IV
	H 3 (as a gas, as luminous paint, or adsorbed on solid material)	VII
Tungsten (74)	W 181	IV
	W 185	IV
	W 187	IV
Uranium (92)	U 230	II
	U 232	I
	U 233 (F)	II
	U 234	II
	U 235 (F)	III
	U 236	II
	U 238	III
	U Natural	III
	U Enriched (F)	III
	U Depleted	III
Vanadium (23)	V 48	IV
	V 49	III
Xenon (54)	Xe 125	III
	Xe 131 m	III
	Xe 131 m (uncompressed).**	V
	Xe 133	III
	Xe 133 (uncompressed).**	VI
	Xe 135	II
	Xe 135 (uncompressed).**	V
Ytterbium (70)	Yb 175	IV
Yttrium (39)	Y 88	III
	Y 90	IV
	Y 91 m	III
	Y 91	III
	Y 92	IV
	Y 93	IV
Zinc (30)	Zn 65	IV
	Zn 69 m	IV
	Zn 69	IV
Zirconium (40)	Zr 93	IV
	Zr 95	III
	Zr 97	IV

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*Atomic number shown in parentheses.

**Uncompressed means at a pressure not exceeding one atmosphere.

***Atomic weight shown after the radionuclide symbol.

m—Metastable state.

(F) Fissile material.

APPENDIX D—TESTS FOR SPECIAL FORM LICENSED MATERIAL

1. *Free Drop*—A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in such a position as to suffer maximum damage.

2. *Percussion*—Impact of the flat circular end of a 1 inch diameter steel rod weighing 3 pounds, dropped through a distance of 40 inches. The capsule or material shall be placed on a sheet of lead, of hardness number 3.5 to 4.5 on the Vickers scale, and not more than 1 inch thick, supported by a smooth essentially unyielding surface.

3. *Heating*—Heating in air to a temperature of 1,475° F. and remaining at that temperature for a period of 10 minutes.

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4. *Immersion*—Immersion for 24 hours in water at room temperature. The water shall be at pH 6–pH 8, with a maximum conductivity of 10 micromhos per centimeter.

33 FR 1762

The record keeping and reporting requirements contained in this part have been approved by the Bureau of the Budget in accordance with the Federal Reports Act of 1942.

31 FR 9941

B.1.2 10 CFR §§73.30-36, PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIAL IN TRANSIT

PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIAL IN TRANSIT

§ 73.30 General requirements.

(a) Except as specified in § 73.36(a) or as otherwise authorized pursuant to § 73.30(f), each licensee who transports or who delivers to a carrier for transport either uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium, or any combination of these materials, which is 5,000 grams or more computed by the formula, grams=(grams contained U-235)+2.5 (grams U-233+grams plutonium), shall make arrangements to assure that such special nuclear material will, if a common or contract carrier is used, be transported under the established procedures of a carrier which provides a system for the physical protection of valuable material in transit and requires an exchange of hand-to-hand receipts at origin and destination and at all points enroute where there is a transfer of custody.

(b) Transit times of shipments other than those specified in § 73.1(b)(3) shall be minimized and routes shall be selected to avoid areas of natural disaster or civil disorders. Such shipments shall be preplanned to assure that deliveries occur at a time when the receiver at the final delivery point is present to accept receipt of shipment.

(c) Special nuclear material shall be shipped in containers which are sealed by tamper indicating type seals. The container shall also be locked if it is not in another container or vehicle which is locked. If inspection of the container or vehicle is not required by State or local authorities before final destination, the outermost container or vehicle shall also be sealed by tamper indicating type seals. No container weighing 500 pounds or less shall be shipped in open trucks, railroad flat cars or box cars and ships. This paragraph does not apply to shipments of quantities specified in § 73.1(b)(3).

(d) When guards are used pursuant to §§ 73.31(c)(1), 73.31(c)(2), 73.33 and 73.35, the licensee shall not permit an individual to act as a guard unless there is documentation that the individual has been qualified by demonstrating an understanding of his duties and responsibilities. The licensee or his agent shall have documentation that guards have been requalified annually.

(e) By January 7, 1974, each licensee shall submit a plan outlining the procedures that will be used to meet the requirements of §§ 73.30 through 73.36 and 73.70(g) including a plan for the selection, qualification, and training of armed escorts, or the specification and design of a specially designed truck or trailer as appropriate. This plan shall be followed by the licensee after March 6, 1974.

(f) A licensee or applicant for a license may apply to the Commission for approval of proposed procedures for transport of special nuclear material in a manner not otherwise authorized by the regulations of this part. Each application shall include a description and quantity of the special nuclear material involved, the origin and destination, the carriers to be used, the expected time in transit, the number of transfer points, the communications to be used, the vehicle visual identification, and the cargo security and surveillance measures to be used.

(g) Paragraphs (b), (c), (d), and (f) of this section are effective March 6, 1974.

§ 73.31 Shipment by road.

(a) All shipments by road shall be made without any scheduled intermediate stops to transfer special nuclear material or other cargo between the facility from which it is shipped and the facility of the receiver.

(b) All motor vehicles used to transport special nuclear material shall be equipped with a radiotelephone which can communicate with a licensee or his agent. The licensee or agent with whom communications shall be maintained for different segments of the shipment shall be predesignated before a shipment is made. Calls to such licensee or agent shall be made at least every 2 hours when radiotelephone or conventional telephone coverage along the route is available to relay position and projected route. Call frequency may extend up to 5 hours when radiotelephone or conventional telephone coverage is not available along the preplanned route, at which time a conventional telephone call shall be made. In the event no call is received in accordance with these requirements, the licensee or his agent shall immediately notify an appropriate law enforcement authority and the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of this part.

(c) A shipment shall be accompanied by at least two people in the vehicle containing the shipment, which may be two drivers or one driver and an authorized individual. The vehicle containing the shipment shall be under continuous visual surveillance, or one of the drivers or authorized individuals shall be in the cab of the vehicle, awake, and not in a sleeper berth. The shipment shall be further protected by one of the following methods:

(1) An armed escort consisting of at least two guards shall accompany the shipment in a separate escort vehicle. Escorts shall maintain continuous vigilance for the presence of conditions or situations which might threaten the security of the shipment, take such action as circumstances might require to avoid interference with continuous safe passage of the cargo vehicle, provide assistance to, or summon aid for crew of cargo vehicles in case of emergency, check seals and locks at each stop where time permits, and observe the cargo vehicle and adjacent areas during stops or layovers. Continuous radio communication capability shall be provided between the cargo vehicle and the escort vehicle. Escort vehicles shall also be equipped with a radiotelephone. The licensee may use his own employees as armed escorts or he may use an agent. Only the driver is required in the vehicle containing special nuclear material for shipments involving an average of less than an hour in transportation, if communication is maintained during the course of the shipment with the licensee or agent monitoring the shipment.

(2) The shipment shall be made in a specially designed truck or trailer which reduces the vulnerability to diversion. Design features of the truck or trailer shall permit immobilization of the van and provide barriers or deterrents to physical penetration of the cargo compartment unless armed guards are also used in which case immobilization of the vehicle is not required.

(d) Transfers to and from other modes of transportation shall be in accordance with § 73.35.

(e) Vehicles shall be marked on top with identifying letters or numbers which will permit identification of the vehicle under daylight conditions from the air in clear weather at 1,000 feet above ground level. The same code of letters and numbers as those used on the top shall also be marked on the sides and rear of the vehicle to permit identification from the ground.

(f) This section is effective March 6, 1974.

§ 73.32 Shipment by air.

(a) Except as specifically approved by the Nuclear Regulatory Commission, no shipment of special nuclear material shall be made in passenger aircraft in excess of (1) 20 grams or 20 curies, whichever is less, of plutonium or uranium-233, or (2) 350 grams of uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope).

(b) In shipments on cargo aircraft of either uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233 or plutonium, or any combination of these materials which is 5,000 grams or more computed by the formula, grams=(grams contained U-235) + 2.5(grams U-233 + grams plutonium), transfers shall be in accordance with § 73.35. Transfers shall be minimized.

(c) Export shipments shall be escorted by an unarmed authorized individual, who may be a crew member, from the last terminal in the United States until the shipment is unloaded at a foreign terminal. He shall perform monitoring duties at foreign terminals as described in § 73.35.

(d) Paragraph (c) of this section is effective March 6, 1974.

§ 73.33 Shipment by rail.

(a) A shipment by rail shall be escorted by two guards, in the shipment car or an escort car of the train, who shall keep the shipment cars under observation and who shall detrain at stops when practicable and time permits to guard the shipment cars under observation, and check car or container locks and seals. Radiotelephone communication shall be maintained with a licensee or his agent to relay position every 2 hours or less, and at scheduled stops in the event that radiotelephone coverage was not available in the last 5 hours before the stop. The licensee or agent with whom communications shall be maintained for different segments of the shipment shall be predesignated before a shipment is made. In the event no call is received in accordance with these requirements, the licensee or his agent shall immediately notify an appropriate law enforcement authority and the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of this part.

(b) Transfers shall be in accordance with § 73.35.

(c) This section is effective March 6, 1974.

§ 73.34 Shipment by sea.

(a) Shipments shall be made on vessels making the minimum ports of call. Transfers to and from other modes of transportation shall be in accordance with § 73.35. There shall be no scheduled transfers to other ships. At domestic ports of call where other cargo is transferred, the shipments shall be protected in accordance with § 73.35(a).

(b) The shipment shall be placed in a secure compartment which is locked and sealed. Locks and seals shall be periodically inspected in transit, if accessible, by an escort or crew member.

(c) Export shipments shall be escorted by an unarmed authorized individual, who may be a crew member, from the last port in the United States until the shipment is unloaded at a foreign port. He shall perform monitoring duties at foreign ports as described in § 73.35.

(d) Ship-to-shore communications shall be available, and a ship-to-shore contact shall be made every twenty-four hours to relay position information, and the status of the shipment, which shall be determined by a daily inspection where possible. This information shall be sent, as often as it is available, to the licensee or his agent who makes the arrangements for the protection of the shipment.

(e) This section is effective March 6, 1974.

§ 73.35 Transfer of special nuclear material.

All transfers shall be monitored by a guard. An alternate guard shall be designated at all transfer points to substitute, if necessary. Monitoring of special nuclear material transfers shall be conducted as follows:

(a) At scheduled intermediate stops where special nuclear material is not scheduled for transfer, the guard shall observe the opening of the cargo compartment and assure that the shipment is not removed. The guard shall maintain continuous visual surveillance of the cargo compartment. Continuous visual surveillance of the cargo compartment shall be maintained up to the time the vehicle is ready to depart. The guard shall observe the vehicle until it has departed, and shall notify the licensee or his agent of the latest status immediately thereafter.

(b) At points where special nuclear material is transferred from a vehicle to storage, from one vehicle to another, or from storage to a vehicle, the guard shall keep the shipment under continuous visual surveillance by observing the opening of the cargo compartment of the incoming vehicle and assuring that the shipment is complete by checking locks and/or seals. Continuous visual surveillance of a shipment shall be maintained at all times it is in the terminal or in storage. Shipments shall be preplanned in order to avoid storage times in excess of 24 hours. Continuous visual surveillance of the cargo compartment shall be maintained up to the time the vehicle is ready to depart from the terminal. The guard shall observe the vehicle until it has departed, and shall notify the licensee or his agent of the latest status immediately thereafter.

(c) The guard shall be required to immediately notify the carrier and the licensee who made the arrangements for protection of special nuclear material of any deviation from or attempted interference with schedule or routing.

(d) This section is effective March 6, 1974.

§ 73.36 Miscellaneous requirements.

(a) Each licensee who takes delivery of special nuclear material free on board (f.o.b.) the point at which it is delivered to a carrier for transport shall make the arrangements to assure that such special nuclear material will be protected in transit as prescribed in §§ 73.30 through 73.35, rather than the person who delivers such shipment to the carrier for transport.

(b) Each licensee who imports special nuclear material shall make arrangements to assure that such material will be protected in transit as follows:

(1) An individual designated by the licensee or his agent, or as specified by a contract of carriage, shall confirm the container count and examine locks and/or seals for evidence of tampering, at the first place in the United States at which the shipment is discharged from the arriving carrier.

(2) The shipment shall be protected at the first terminal at which it arrives in the United States and all subsequent terminals as provided in §§ 73.30 through 73.35 and paragraphs (c) and (f) of this section.

(c) (1) Each licensee who delivers special nuclear material to a carrier for transport shall immediately notify the consignee by telephone, telegraph, or teletype, of the time of departure of the shipment, and shall notify or confirm with the consignee the method of transportation, including the names of carriers, and the estimated time of arrival of the shipment at its destination. (2) In the case of a shipment free on board (f.o.b.) the point where it is delivered to a carrier for transport, each licensee shall, before the shipment is delivered to the carrier, obtain written certification from the licensee who is to take delivery of the shipment at the f.o.b. point that the physical protection arrangements required by §§ 73.30 through 73.35 for licensed shipments have been made. When a contractor exempt from the requirements for a Commission license is the consignee of a shipment, the licensee shall, before the shipment is delivered to the carrier, obtain written certification from the contractor who is to take delivery of the shipment at the f.o.b. point that the physical protection arrangements required by ERDA Manual or NRC Manual Chapters 2401 or 2405, as appropriate, have been made.

(c) (3) Each licensee who delivers special nuclear material to a carrier for transport or releases special nuclear material f.o.b at the point where it is delivered to a carrier for transport shall also make arrangements with the consignee to be notified immediately by telephone and telegraph or teletype, of the arrival of the shipment at its destination.

(d) In addition to complying with the requirements specified in paragraphs (c) and (f) of this section, each licensee who exports special nuclear material shall comply with the requirements specified in §§ 73.30 through 73.35, as applicable, up to the first point where the shipment is taken off the vehicle outside the United States. The licensee shall also make arrangements with the consignee to be notified immediately by telephone and telegraph, teletype, or cable, of the arrival of the shipment at its destination, or of any such shipment that is lost or unaccounted for after the estimated time of arrival at its destination.

(e) Each licensee who receives a shipment of special nuclear material shall immediately notify by telephone and telegraph or mailgram, or facsimile,† the person who delivered the material to a carrier for transport and the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of the arrival of the shipment at its destination. When an Energy Research and Development Administration (ERDA) license-exempt contractor is the consignee, the licensee who is the consignor shall notify by telephone and telegraph, or mailgram, or facsimile,† the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of the arrival of the shipment at its destination immediately upon being notified of the receipt of the shipment by the license-exempt contractor as arranged pursuant to paragraph (c)(3) of this section. In the event such a shipment fails to arrive at its destination at the estimated time, the consignee, if a licensee, or in the case of an export shipment, the licensee who exported the shipment, shall immediately notify by telephone and telegraph, or mailgram, or facsimile,† the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of this part, and the licensee or other person who delivered the material to a carrier for transport. The licensee who made the physical protection arrangements shall also immediately notify by telephone and telegraph, or teletype, the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of the action being taken to trace the shipment.

(f) Each licensee who makes arrangements for physical protection of a shipment of special nuclear material as required by §§ 73.30 through 73.36 shall immediately conduct a trace investigation of any shipment that is lost or unaccounted for after the estimated arrival time and file a report with the Commission as specified in § 73.71. If the licensee who conducts the trace investigation is not the consignee, he shall also immediately report the results of his investigation by telephone and telegraph, or teletype to the consignee.

(g) Paragraphs (a), (b), (c) and (d) of this section are effective March 6, 1974.

B.1.3 10 CFR §20.205, PROCEDURES FOR PICKING UP, RECEIVING, AND OPENING PACKAGES

§ 20.205 Procedures for picking up, receiving, and opening packages.

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify the final delivering carrier and, by telephone and telegraph, mailgram, or facsimile,† the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group [1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours.

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour, the licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier.

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

B.2 DEPARTMENT OF TRANSPORTATION REGULATIONS

B.2.1 49 CFR §173.393, GENERAL PACKAGING AND SHIPPING REQUIREMENTS

§ 173.393 General packaging and shipment requirements.

(a) Unless otherwise specified, all shipments of radioactive materials must meet all requirements of this section, and must be packaged as prescribed in §§ 173.391 through 173.396.

(b) The outside of each package must incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that the package has not been illicitly opened.

(c) The smallest outside dimension of any package must be 4 inches or greater.

(d) Each radioactive material must be packaged in a packaging which has been designed to maintain shielding efficiency and leak tightness, so that, under conditions normally incident to transportation, there will be no release of radioactive material. If necessary, additional suitable inside packaging must be used. Each package must be capable of meeting the standards in §§ 173.398(b) and 173.24.

(1) Internal bracing or cushioning, where used, must be adequate to assure that, under the conditions normally incident to transportation, the distance from the inner container or radioactive material to the outside wall of the package remains within the limits for which the package design was based, and the radiation dose rate external to the package does not exceed the transport index number shown on the label. Inner shield closures must be positively secured to prevent loss of the contents.

(e) The packaging must be designed, constructed, and loaded so that during transport:

(1) The heat generated within the package because of the radioactive materials present will not, at any time during transportation, affect the efficiency of the package under the conditions normally incident to transportation, and

(2) The temperature of the accessible external surfaces of the package will not exceed 122° F. in the shade when fully loaded, assuming still air at ambient temperature. If the package is transported in a transport vehicle consigned for the sole use of the consignor, the maximum accessible external surface temperature shall be 180° F.

(f) Pyrophoric materials, in addition to the packaging prescribed in this subpart, must also meet the packaging requirements of § 173.134 or § 173.154. Pyrophoric radioactive liquids may not be shipped by air.

(g) Liquid radioactive material in Type A quantities must be packaged in or within a leak-resistant and corrosion-resistant inner containment vessel. In addition:

(1) The packaging must be adequate to prevent loss or dispersal of the radioactive contents from the inner containment vessel if the package were subjected to the 9 meter (30-foot) drop test prescribed in § 173.398(c)(2)(i); and either

(2) Enough absorbent material must be provided to absorb at least twice the volume of radioactive liquid contents. The absorbent-material may be located outside the radiation shield only if it can be shown that if the radioactive liquid contents were taken up by the absorbent material the resultant dose rate at the surface of the package would not exceed 1,000 millirem per hour; or

(3) A secondary leak-resistant and corrosion-resistant containment vessel must be provided to retain the radioactive contents under the normal conditions of transport as prescribed in § 173.398(b), assuming the failure of the inner primary containment vessel.

(h) There must be no significant removable radioactive surface contamination on the exterior of the package (see § 173.397).

(i) Except for shipments described in paragraph (j) of this section, all radioactive materials must be packaged in suitable packaging (shielded, if necessary) so that at any time during the normal conditions incident to transportation the radiation dose rate does not exceed 200 millirem per hour at any point on the external surface of the package, and the transport index does not exceed 10.

(j) Packages for which the radiation dose rate exceeds the limits specified in paragraph (i) of this section, but does not exceed at any time during transportation any of the limits specified in paragraphs (j) (1) through (4) of this section may be transported in a transport vehicle which has been consigned as exclusive use (except aircraft). Specific instructions for maintenance of the exclusive use (sole use) shipment controls must be provided by the shipper to the carrier. Such instructions must be included with the shipping paper information:

(1) 1,000 millirem per hour at 3 feet from the external surface of the package (closed transport vehicle only);

(2) 200 millirem per hour at any point on the external surface of the car or vehicle (closed transport vehicle only);

(3) Ten millirem per hour at any point 2 meters (six feet) from the vertical planes projected by the outer lateral surface of the car or vehicle; or if the load is transported in an open transport vehicle, at any point 2 meters (six feet) from the vertical planes projected from the outer edges of the vehicle.

(4) 2 millirem per hour in any normally occupied position in the car or vehicle, except that this provision does not apply to private motor carriers.

(k) [Reserved]

(l) Packages consigned for export are also subject to the regulations of the foreign governments involved in the shipment. See §§ 173.8, 173.9, and 173.393b. (The regulations of the International Atomic Energy Agency (IAEA) are used by most foreign governments.)

(m) Prior to the first shipment of any package, the shipper shall determine by examination or appropriate test that:

(1) The packaging meets the specified quality of design and construction; and

(2) The effectiveness of the shielding and containment, and, where necessary, the heat transfer characteristics of the package are within the limits applicable to or specified for the package design.

(n) Prior to each shipment of any package, the shipper shall insure by examination or appropriate test that:

(1) The package is proper for the contents to be shipped;

(2) The packaging is in unimpaired physical condition except for superficial marks;

(3) Each closure device of the packaging, including any required gasket, is properly installed and secured and free of defects;

(4) For a fissile material, any moderator and neutron absorber, if required, is present in proper condition;

(5) Any special instructions for filling, closing, and preparation of the package for shipment have been followed;

(6) Each closure, valve, and any other opening of the containment system through which the radioactive content might escape is properly closed and sealed;

(7) Each package containing liquid in excess of a Type A quantity and destined for air shipment is tested to demonstrate that it is leak tight under an ambient atmospheric pressure differential of at least 0.5 atmosphere (absolute) (7.3 p.s.i.a. or 0.5 kg./cm.²); the test may be conducted on the entire containment system or on any receptacle or vessel within the containment system, as appropriate to determine compliance with the requirement;

(8) If the maximum normal operating pressure of a package is likely to exceed 0.35 kg./cm.² (gage), the internal pressure of the containment system will not exceed the design pressure during transportation; and

(9) External radiation and contamination levels are within the allowable limits.

(o) No person may offer for transportation a package of radioactive materials until the temperature of the packaging system has reached equilibrium (see also paragraph (e) of this section) unless, for the specific contents, he has ascertained that the maximum applicable surface temperature limits cannot be exceeded.

(p) No person may offer for transportation aboard a passenger carrying aircraft any radioactive material unless that material is intended for use in, or incident to, research, or medical diagnosis or treatment, or is excepted under the provisions of § 175.10 of this subchapter.

[Amdt. 173-3, 33 FR 14926, Oct. 4, 1968, as amended by Amdt. 173-6, 34 FR 7162, May 1, 1969; Amdt. No. 173-66, FR 17970, Sept. 2, 1972; Amdt. 173-90, 39 FR 45241, Dec. 31, 1974; Amdt. 173-94A, 41 FR 40684, Sept. 20, 1976]

B.2.2 49 CFR §173.391, SMALL QUANTITIES OF RADIOACTIVE MATERIALS AND RADIOACTIVE DEVICES

§ 173.391 Limited quantities of radioactive materials and radioactive devices.

(a) Limited quantities of radioactive materials in normal form not exceeding 0.01 millicurie of Group I radionuclides; 0.1 millicurie of Group II radionuclides; 1 millicurie of Groups III, IV, V, or VI radionuclides; 25 curies of Group VII radionuclides; tritium oxide in aqueous solution with a concentration not exceeding 0.5 millicuries per milliliter and with a total activity per package of not more than 3 curies; or 1 millicurie of radioactive material in special form; and not containing more than 15 grams of uranium-235 are excepted from specification packaging, marking, and labeling, and are excepted from the provisions of § 173.393, if the following conditions are met:

(1) The materials are packaged in strong tight packages such that there will be no leakage of radioactive materials under conditions normally incident to transportation.

(2) The package must be such that the radiation dose rate at any point on the external surface of the package does not exceed 0.5 millirem per hour.

(3) There must be no significant removable radioactive surface contamination on the exterior of the package (see § 173.397).

(4) The outside of the inner container must bear the marking "Radioactive."

(b) Manufactured articles such as instruments, clocks, electronic tubes or apparatus, or other similar devices, having limited quantities of radioactive materials (other than liquids) in a nondispersible form as a component part, are excepted from specification packaging, marking, and labeling, and are excepted from the provisions of § 173.393, if the following conditions are met:

NOTE 1: For radioactive gases, the requirement for the radioactive material to be in a nondispersible form does not apply.

(1) Radioactive materials are securely contained within the devices, or are securely packaged in strong, tight packages, so that there will be no leakage of radioactive materials under conditions normally incident to transportation.

(2) The radiation dose rate at four inches from any unpackaged device does not exceed 10 millirem per hour.

(3) The radiation dose rate at any point on the external surface of the outside of the package may not exceed 0.5 millirem per hour. However, for exclusive use shipments only, the radiation at the external surface of the package or the item may exceed 0.5 millirem per hour, but must not exceed 2 millirem per hour.

(4) There must be no significant removable radioactive surface contamination on the exterior of the package (see § 173.397).

(5) The total radioactivity content of a package containing radioactive devices must not exceed the quantities shown in the following table:

Transport group	Quantity in curies	
	Per device	Per package
I	0.0001	0.001
II	0.001	0.05
III	0.01	3
IV	0.05	3
V or VI	1	1
VII	25	200
Special form	0.05	20

(6) No package may contain more than 15 grams of fissile material.

(c) A manufactured article, other than a reactor fuel element, in which the only radioactive material is metallic natural or depleted uranium or natural thorium or alloys thereof, is excepted from specification packaging, marking, and labeling, and is excepted from the provisions of § 173.393, if the following conditions are met:

(1) The radiation dose rate at any point on the external surface of the outside container does not exceed 0.5 millirem per hour;

(2) There must be no significant radioactive surface contamination on the exterior of the package. To determine whether "significant," the standard in § 173.397 must be used.

(3) The total radioactivity content of each article must not exceed 3 curies.

(4) The outer surface of the uranium or thorium is enclosed in a non-radioactive, sealed, metallic sheath.

NOTE: Such articles may be packagings for the transportation of radioactive materials.

(d) Shipments made under this section for transportation are not subject to Subpart F of Part 172 of this subchapter, to Part 174 of this subchapter except § 174.24 and to Part 177 of this subchapter except § 177.817.

B.2.3. 49 CFR 173.392 LOW SPECIFIC ACTIVITY RADIOACTIVE MATERIAL

§ 173.392 Low specific activity radioactive material.

(a) Low specific activity (LSA) radioactive materials, other than materials consigned as exclusive use, are exempt from the provisions of § 173.393(a) through (e) and (g). However, they must be packaged in accordance with the requirements of § 173.395 and must be marked and labeled as required in §§ 172.300 and 172.400 of this subchapter.

(b) LSA radioactive materials which are transported in a transport vehicle (except aircraft) and consigned as exclusive use are exempt from specification packaging, marking, and labeling, provided the shipment meets the requirements of paragraph (c) or (d) of this section.

(c) Packaged shipments of low specific activity materials transported in transport vehicles (except aircraft) assigned for the sole use of that consignor must comply with the following:

(1) Materials must be packaged in strong, tight packages so that there will be no leakage of radioactive material under conditions normally incident to transportation.

(2) Packages must not have any significant removable surface contamination (see § 173.397).

(3) External radiation levels must comply with § 173.393(j).

(4) Shipments must be loaded by consignor and unloaded by consignee from the transport vehicle in which originally loaded.

(5) There must be no loose radioactive material in the car or vehicle.

(6) Shipment must be braced so as to prevent leakage or shift of lading under conditions normally incident to transportation.

(7) Except for shipments of uranium or thorium ores, unconcentrated, the transport vehicle must be placarded with the placards prescribed in accordance with § 172.500 of this subchapter, as appropriate.

(8) The outside of each outside package must be stencilled or otherwise marked "Radioactive—LSA."

(9) Specific instructions for maintenance of exclusive use (sole use) shipment controls must be provided by the shipper to the carrier. Such instructions must be included with the shipping paper information.

(d) Unpackaged (bulk) shipments of low specific activity materials transported in closed transport vehicles (except aircraft) assigned for the sole use of that consignor must comply with the following:

(1) Authorized materials are limited to the following:

(i) Uranium or thorium ores and physical or chemical concentrates of those ores.

(ii) Uranium metal or natural thorium metal, or alloys of these materials; or

(iii) Materials of low radioactive concentration, if the average estimated radioactivity concentration does not exceed 0.001 millicurie per gram and the contribution from Group I material does not exceed one percent of the total radioactivity.

(iv) Objects of nonradioactive material externally contaminated with radioactive material, if the radioactive material is not readily dispersible and the surface contamination, when averaged over one square meter, does not exceed 0.0001 millicurie per square centimeter of Group I radionuclides or 0.001 millicurie per square centimeter of other radionuclides. Such objects must be suitably wrapped or enclosed.

(2) Bulk liquids must be transported in the following:

(i) Specification 103CW, 111A60W7 (§§ 179.200, 179.201, 179.202 of this subchapter) tank cars. Bottom openings in tanks prohibited.

(ii) Spec. MC 310, MC 311, MC 312, or MC 331 (§ 178.330, § 178.331, § 178.337, or § 178.343 of this subchapter) cargo tanks. Authorized only where the radioactivity concentration does not exceed 10 percent of the specified low specific activity levels (see § 173.389(c)). The requirements of § 173.393(g) do not apply to these cargo tanks. Bottom fittings and valves are not authorized. Trailer-on-flat-car service is not authorized.

(3) External radiation levels must comply with paragraphs (2), (3), and (4) of § 173.393(j).

(4) Shipments must be loaded by the consignor, and unloaded by the consignee from the transport vehicles in which originally loaded.

(5) Except for shipments of uranium or thorium ores, unconcentrated, the transport vehicle must be placarded with the placards prescribed in accordance with § 172.500 of this subchapter, as appropriate.

(6) There must be no leakage of radioactive materials from the vehicle.

(7) Specific instructions for maintenance of exclusive use (sole use) shipment controls must be provided by the shipper to the carrier. Such instructions must be included with the shipping paper information.

[Amdt. 173-3, 33 FR 14925, Oct. 4, 1968; 33 FR 19823, Dec. 27, 1968]

NOTE: For amendments to § 173.392 see the List of CFR Sections Affected appearing in the Finding Aids section of this volume.

Appendix C

ASSUMPTIONS UTILIZED FOR SOCIOECONOMIC IMPACT ASSESSMENTS

Appendix C

ASSUMPTIONS UTILIZED FOR SOCIOECONOMIC IMPACT ASSESSMENTS

The staff combined information collected from a literature survey and from personal and written communications with Chem-Nuclear personnel and with planners and other authorities in the Barnwell-Aiken area to independently develop a set of assumptions useful for analyzing the socioeconomic impacts of the disposal facility. Because very little Chem-Nuclear employee information was available, a relatively large number of assumptions had to be developed. Therefore, the impact assessments in Sect. 4.3.1, when quantified, should be read with caution. When feasible, the staff calculated high and low ranges for quantifiable impacts. Although some of the ranges are rather wide and may seem ambiguous, the staff feels that no ambiguity is involved. Depending on the series of assumptions utilized, the facility-related impacts have probably occurred somewhere within the ranges specified. The assumptions were as follows:

1. The labor recruiting area for the project includes Barnwell, Aiken, Bamberg, and Allendale counties (ref. 1 and C. Rogers, Director, Barnwell Job Service, personal communication, Feb. 11, 1981).

2. The facility-related workers [both direct employees and induced (or secondary) workers] have chosen to settle either in the Barnwell area or in Aiken County (assumption based primarily on the personal communication with C. Rogers and on a personal communication with C. Towsley, Southeast Personnel Manager, Chem-Nuclear Systems, Inc., Feb. 12, 1981). Therefore, it was assumed that Barnwell city, Barnwell County, and Aiken city, and Aiken County have absorbed the majority of socioeconomic impacts induced by in-migration.

3. To determine settlement patterns and reduce calculation complexities and because Barnwell and Aiken are the major population centers within their respective counties, it was assumed that all of the facility-related in-migrating workers (and their families) live either in Barnwell or Aiken. Accounting for (1) the distances from these communities to the project site and (2) the relative sizes (comparative populations) of these committees, and utilizing a population gravity model,[2,3] the staff estimates that (1) 74 to 96% of the nonlocal direct workers live in Barnwell, (2) 4 to 26% of the nonlocal direct workers live in Aiken, (3) 98 to 100% of the nonlocal secondary workers live in Barnwell, and (4) at most, only 2% of the nonlocal secondary workers live in Aiken.

4. The impacts of the facility on employment, population, housing, school enrollment, and some other areas were calculated utilizing the following assumptions:

a. At the disposal site, 199 persons are employed (162 hourly and 37 salaried employees) (C. Towsley, Southeast Personnel Manager, Chem-Nuclear Systems, Inc., Feb. 12, 1981).

b. Approximately 75 to 85% of the Chem-Nuclear employees were hired locally (Aiken-Barnwell-Allendale-Bamberg labor market area) (C. Towsley, Southeast Personnel Manager, Chem-Nuclear Systems, Inc., Feb. 12, 1981).

c. Each Chem-Nuclear job induces about 0.6 secondary jobs. This employment multiplier was calculated using economic base theory[4-7] and county business pattern statistics.[8,9]

d. Most (90 to 95%) of the secondary jobs were filled by local workers. This assumption (and assumption b) implies that the local employees who fill the secondary jobs were either previously unemployed or, if previously employed, were replaceable from among the ranks of the locally unemployed. Based on the sizes of the local labor pools, the composition of the work forces, and the unemployment statistics (see Sect. 3.4.3), this assumption appears reasonable.

e. About 20 to 25% of the in-migrating workers (both direct and secondary) were not married.[2]

f. About 50% of the unmarried in-migrating workers (both direct and secondary) were not married.[2]

g. All married in-migrating workers (both direct and secondary) brought their families with them.

h. None of the facility-induced secondary jobs were filled by members of the families of in-migrating direct workers.

i. The family size for each married in-migrating worker (both direct and secondary) averaged about 3.6 (spouse plus 1.6 dependents).[2]

j. About 60% of the in-migrating children were school-age children (5-18 years old).[2]

5. To determine facility-induced personal income, the staff assumed that each Chem-Nuclear hourly employee earns $5.90/h (C. Towsley, Southeast Personnel Manager, Chem-Nuclear Systems, Inc., Feb. 12, 1981) and that each Chem-Nuclear salaried employee earns, on the average $20,000 each year. Utilizing basic economic consumption theory, the staff calculated a facility-generated income multiplier ranging from 2.0 to 3.33; that is, each Chem-Nuclear payroll dollar was assumed to induce an additional $1.00 to $2.33 of secondary earnings in the local economies.

REFERENCES FOR APPENDIX C

1. Lower Savannah Council of Governments, *Lower Savannah Region, Overall Economic Development Plan, 1981-1985,* Aiken, S.C., October 1980.

2. Mountain West Research, Inc., *Construction Worker Profile: Final Report,* Washington, D.C., December 1975.

3. F. L. Leistritz and S. H. Murdock, "Research Methodology Applicable to Community Adjustment to Public Land Use Alternatives," at the Forum on the Economics of Public Land Use in the West, Reno, Nev., March 1977.

4. E. J. Stenehjem and J. E. Metzger, *A Framework for Protecting Employment and Population Changes Accompanying Energy Development,* Report ANL/AA-14, Argonne National Laboratory, Argonne, Ill., May 1980.

5. G. E. Thompson, "An Investigation of the Local Employment Multiplier," *Rev. Econ. Stat.* 41: 61-67 (1959).

6. G. H. Hildebrand and A. Mare, Jr., "The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47," *Rev. Econ. Stat.* 32: 241-49 (1950).

7. K. Sasaki, "Military Expenditures and the Employment Multiplier in Hawaii," *Rev. Econ. Stat.*, 45: 298-304 (1963).

8. U.S. Department of Commerce, Bureau of the Census, *County Business Patterns, 1977: South Carolina,* CBP-77-42, Washington, D.C., July 1979.

9. U.S. Department of Commerce, Bureau of the Census, *Compendium of Public Employment, 1977 Census of Governments,* Vol. 3, No. 2, Washington, D.C., July 1979.

Appendix D

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL RADIOACTIVE MATERIAL LICENSE

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SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

RADIOACTIVE MATERIAL LICENSE

Pursuant to the Atomic Energy and Radiation Control Act, Sections 1-400.11 through 1-400.16 of the 1962 Code of Laws of South Carolina and Supplement thereto, and the South Carolina Department of Health and Environmental Control Rules and Regulations, pertaining to Radiation Control Part III, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess and transfer radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules and regulations of the South Carolina Department of Health and Environmental Control now or hereafter in effect and to any conditions specified below.

Amendment No. 28 amends

LICENSEE	
1. Name Chem-Nuclear Systems, Inc. Barnwell Waste Management Facility	3. License Number 097 in its entirety.
2. Address P.O. Box 726 Barnwell, South Carolina 29812	4. Expiration Date December 31, 1981

5. Radioactive Material (Element and Mass Number)	6. Chemical and / or Physical Form	7. Maximum Radioactivity and / or quantity of material which licensee may possess at any one time.
A. Any radioactive material excluding source material and special nuclear material.	A. Dry packaged radioactive waste except as authorized in this license.	A. 50,000 curies.
B. Source material	B. Dry packaged radioactive waste except as authorized in this license.	B. 60,000 pounds.
C. Special nuclear material	C. Dry packaged radioactive waste except as authorized in this license.	C. 350 grams of Uranium 235 or 200 grams of Uranium 233 or 200 grams of Plutonium provided that the sum of the ratio of the quantities of U 235, U 233, and Pu to the quantities specified above do not exceed unity.

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8. Authorized Use:

A., B., and C. Radioactive waste may be received, transferred, stored and disposed of by shallow land burial. Unless otherwise authorized in this license, only radioactive material consigned for burial shall be received at the site.

General Conditions

9. Unless otherwise specified, the authorized place of use is a site located approximately five miles northwest of Barnwell, South Carolina, in the Seven Pines School District, Red Oak Township, Barnwell County, South Carolina, within the boundary of the land area described in Lease Agreement dated April 6, 1976 as amended.

10. The licensee shall comply with the provisions of Regulation No. 61-63, Title A, State of South Carolina Rules and Regulations for Radiation Control, Part I - General Provisions, Part III - Standards for Protection Against Radiation, and Part VI - Notices, Instructions, and Reports to Workers; Inspections.

11. Operations authorized by this license shall be conducted in accordance with Chem-Nuclear Systems, Inc. Procedure Manual Volumes I and II and Standard Operating Procedures - Barnwell Site Volumes I and II submitted to the Department on October 31, 1980, and subsequent revisions and additions approved by the Department. However, the licensee may, upon notification to the Department but without Department approval, make minor changes to these procedures provided that:

    (a) The change does not affect requirements of any other license condition in this license, and

    (b) The change does not increase the potential for personnel exposures, and

    (c) The changes does not diminish operational safety, and

    (d) The change does not increase the potential for release of radioactive material to unrestricted areas, and

    (e) The change does not reduce the licensee's record keeping and reporting system.

    The licensee shall maintain a record of these changes including evaluations which provide the bases for the change.

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General Conditions continued

12. Operations shall be conducted under the supervision of J.W. Ott, L.B. Hebbard, Jr., D.G. Ebenhack (RPO), J.E. Purvis, J.S. Zawacki, or other individuals designated by the licensee's Radiation Protection Officer upon completion of the licensee's training program.

13. The licensee shall insure that all site personnel have satisfactorily completed the training program requirements as specified in the Chem-Nuclear Systems, Inc. Barnwell Site Training Program. Changes and additions to the program shall be submitted to the Department for review. Time intervals for personnel indoctrination, training, examination, certification, retraining specified in Standard Operating Procedure S20-AD-004, "Barnwell Radioactive Waste Burial Site Personnel Training" shall not be changed without Department approval.

14. The Site Manager or the Manager of Health and Safety shall conduct and document a weekly inspection of site operations and the restricted area of the site.

15. The transportation of radioactive material within the State shall be in accordance with Regulation No. 61-63, Title A, State of South Carolina Rules and Regulations for Radiation Control, RHA 2.22, "Transportation of Radioactive Materials" and Regulation No. 61-83, Regulation for the Transportation of Radioactive Waste Into or Within South Carolina.

16. The licensee shall maintain all records pertinent to the receipt and burial of radioactive material at the location specified in Condition 9 of this license until authorization is given by the Department for transfer or disposal of said records.

17. A monthly site receipt and burial activities report shall be submitted no later than the 10th day of the following month to the Chief, Bureau of Radiological Health, South Carolina Department of Health and Environmental Control, 2600 Bull Street, Columbia, South Carolina 29201.

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General Conditions continued

18. The licensee shall not receive waste in any month in excess of the volume limits specified in the following schedule, except upon special order of the Commissioner. The licensee shall insure that waste generated in South Carolina which is acceptable for burial under all other terms and conditions of this license is received, and that this waste is within the volume limit specified for that month.

Volume Limitation Schedule

Month and Year	Volume Limit in Cubic Feet
November, 1980	144,500
December, 1980	144,500
January, 1981	133,500
February, 1981	133,500
March, 1981	133,500
April, 1981	122,500
May, 1981	122,500
June, 1981	122,500
July, 1981	111,000
August, 1981	111,000
September, 1981	111,000
October, 1981	100,000
November, 1981	100,000
December, 1981	100,000
January, 1982 and each month thereafter or until this condition is otherwise amended.	100,000

19. Except as specifically provdied otherwise by this license, the licensee shall possess and use radioactive material described in Items 5, 6, and 7 of this license and conduct site operations in accordance with statements, representations, procedures, and site criteria, heretofore made by the licensee in application for and subsequent to the issuance of S.C. Radioactive Material License No. 097, and amendments thereto.

Receipt, Acceptance and Inspection Conditions

20. The licensee may only receive waste shipments which have been inspected by a representative of the Department.

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Receipt, Acceptance....

21. The licensee shall not accept radioactive waste for storage or disposal unless the shipper of such waste has a valid, unsuspended Radioactive Waste Transport Permit issued by the Department of Health and Environmental Control of the State of South Carolina.

22. The licensee shall receive advance notification from the shippers of any waste shipment containing unusual hazards or potential unusual hazards including but not limited to, physical, gaseous, chemical or excessive removable contamination on disposal containers shipped inside casks.

23. The licensee shall insure that each Radioactive Shipment Record form used to describe a low-level radioactive waste shipment received at the Barnwell Site has the following certification properly executed by a representative of the shipper, generator of the waste:

"Certification is hereby made to the South Carolina Department of Health and Environmental Control that this shipment of low-level radioactive waste has been inspected in accordance with the requirements of South Carolina Radioactive Material License No. 097, as amended, U.S. Nuclear Regulatory Commission License No. 46-13536-01, as amended, and the effective Barnwell Site Disposal Criteria within 48 hours prior to shipment; and further certification is made that the inspection revealed no items of non-compliance with all applicable laws, rules, and regulations.

Date________________ By:________________

Title and Organization:________________

Telephone No. (   )________________

24. The licensee shall insure that each shipment of radioactive waste delivered to the site is accompanied by a properly executed Radioactive Waste Shipment Certification Form, Part I and Part II. For shipments consisting of more than 75 cubic feet or containing more than one (1) Curie shall also be accompanied by a properly completed and executed Radioactive Waste Shipment Prior Notification and Manifest Form.

25. The licensee shall notify the Department within 24 hours of any arriving waste shipment where a violation of U.S. Department of Transportation regulation or License Condition has been found.

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Waste Constituents and Waste Form Conditions

26. Unless otherwise specified in this license, the licensee shall not receive any liquid radioactive waste regardless of the chemical or physical form. Solidified radioactive waste shall have no detectable free standing liquids. For purposes of this condition, the terminology "no detectable free standing liquids" is defined as follows:

    (a) One percent (1%) liquid by waste volume until December 31, 1980.

    (b) Effective January 1, 1981, one-half percent (0.5%) by waste volume or one gallon of non-corrosive liquids per container, whichever is less.

    In lieu of the requirements of sub-paragraph (b) above, solidified waste containing liquids in excess of one-half percent (0.5%) by waste volume, but less than one percent (1%) liquid by waste volume, may be received and disposed of in approved high integrity containers.

27. The licensee may receive aqueous liquids solidified with one of the following solidification media provided the requirements of other conditions as specified in this license are met.

    (a) Dow media
    (b) Cement
    (c) Urea Formaldehyde
    (d) Asphalt
    (e) Delaware Custom Media
    (f) Solidification media and processes reviewed and approved by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, subject to final approval by the S.C. Department of Health and Environmental Control, Bureau of Radiological Health.

28. The licensee shall not receive evaporator bottoms, concentrates, or other wastes containing free standing liquids unless they meet the requirements as specified in Conditions 26 and 27 of this license, prior to receipt at the site.

29. Ion exchange resins and filter media may be received in a dewatered form for transportation and subsequent burial provided that the requirements of Conditions 26 and 31 are met.

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Waste Constituents......

30. The licensee shall maintain records of complete radiological analyses (quantitative and qualitative) including all transuranic elements for each package containing ion exchange resins received at the site.

31. Effective July 1, 1981, ion exchange resins and filter media containing isotopes with greater than five (5) year half-lives having a specific activity of all these isotopes of 1 microcurie/cubic centimeter or greater must be stabilized by solidification. However, in lieu of solidification, the Department will authorize disposal of these waste forms meeting the free standing liquid requirements of Condition 26 in approved high integrity containers or other approved methods of stabilization.

32. Unless otherwise authorized, the licensee shall not receive waste containing any transuranic elements. However, waste containing less than 10 nanocuries total transuranic nuclides per gram of waste is acceptable provided that the transuranic nuclides are evenly distributed within a homogeneous waste form and are incidental to the total activity. This license condition does not authorize receipt or burial of components or equipment contaminated with transuranic nuclides.

33. Household smoke detectors containing Americium 241 foils which may exceed the transuranic limit of 10 nanorcuries per gram of material may be accepted for disposal provided the entire detector is received for disposal.

34. The licensee shall not receive sealed sources containing more than 5 Curies of radioactive material with half-lives greater than 5 years except in a container approved by the Department before receipt.

35. The licensee shall not receive toluene, xylene, dioxane, scintillation liquids, or other organic liquids with similar chemical properties or containers which have at any time contained any of the liquids mentioned above. However, after complete incineration, the ash and/or residue from these wastes are acceptable.

36. The licensee shall not receive any radioactive waste containing Radium except for:

    (a) Radium contained in solid homogeneous waste forms in which the Radium activity is incidental to the total activity and the concentration of Radium has not been technologically enhanced or,

    (b) Radium contained in the following devices: self-luminous dials, hands of dials, timepieces, compasses, and electron tubes provided that the entire device is received and buried or,

    (c) Radium contained in biological research waste.

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Waste Constituents....

37. The licensee may only receive gaseous radioactive materials of Krypton 85 and Xenon 133 for burial provided they meet the following criteria:

    (a) Burial containers must be U.S. Department of Transportation specification cylinders or U.S. Nuclear Regulatory Commission approved sealed sources.

    (b) Internal pressure of containers may not exceed 1.5 atmospheres.

    (c) Total activity of containers shall not exceed 100 Curies each.

38. Waste containing both toxic chemicals and radioactive materials shall not be received until an independent evaluation of both hazards has been performed. If the chemical hazard exceeds the radiological hazard, the waste containing both radioactive material and chemically toxic waste shall not be buried at the site as described in Condition 9 except as specifically approved by the Department. Records of hazard evaluation of such wastes shall be kept for inspection by the Department.

Contamination Limit Conditions

39. For receipt at the Barnwell Site, all shipments shall comply with contamination control limits as prescribed in U.S. Department of Transportation Regulations, 49 CFR 173.397.

40. Enclosed radioactive material transport vehicles used solely for transporting radioactive materials and marked "For Radioactive Material Use Only" shall not be released from the site if contamination limits exceed the following:

    (a) Fixed contamination of 10mR/hr on contact with the interior surface or 2mR/hr at 3 feet from the interior surface.

    (b) Removable contamination of 2200 dpm/100sq. cm. Beta-Gamma or 220 dpm/100sq. cm. Alpha. This applies to interior and exterior surfaces.

    (c) Fixed contamination of 0.5mR/hr on contact with any exterior surface.

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Contamination Limit.....

41. Vehicles used solely for transporting radioactive material and are not marked "For Radioactive Material Use Only" shall not be released from the site if the contamination limits exceed the following:

    (a) Fixed contamination of 0.5mR/hr at any accessible surface.

    (b) Removable contamination of 2200 dpm/100sq. cm. Beta-Gamma, or 220dpm/100sq. cm. Alpha.

42. Vehicles or items for unrestricted use shall not be released from the site if the contamination limits exceed the following:

    (a) Fixed contamination of 0.1mR/hr at any accessible surface.

    (b) Removable contamination of 220 dpm/100sq. cm. Beta-Gamma, or 22 dpm/100sq. cm. Alpha.

43. The licensee shall perform sandblasting for decontamination purposes on vehicles, equipment or components, with contamination limits in excess of those specified in Condition 41, in a controlled environment.

44. The licensee shall not use its vehicle wash-down facility for any vehicles or equipment with removable contamination limits in excess of those specified in Condition 41 unless specifically approved by the Department.

General Packaging Conditions

45. All radioactive waste shall be packaged in accordance with applicable U.S. Department of Transportation Regulations, U.S. Nuclear Regulatory Commission Regulations 10 CFR Part 71, and the requirements of this license.

46. Unless specifically authorized, all radioactive waste shall be received and buried in containers which have been approved by the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, and subject to final approval by the Department. Cardboard boxes and corrugated paper drums are not acceptable burial containers.

47. The licensee shall insure that any package used as the final burial container shall be of such material and construction that there will be no significant chemical, galvanic, or other reaction among the packaging components, or between the packaging components and the package contents.

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General Packaging.....

48. The licensee shall insure that appropriate lifting devices of sufficient length to allow retrieval without physically entering the cask have been provided and securely attached to single containers and palletized containers within a cask.

49. The licensee is not authorized to open any packages at its facility, except for the following:

(a) For purposes of repairing or repackaging damaged containers.

(b) For purposes of inspecting to insure compliance with this license.

(c) For purposes of returning outer shipping containers.

(d) For purposes of retrieving shipment documentation and confirming package contents.

Radioactive Biological Material Packaging Condition

50. Radioactive biological materials shall be doubly packaged in unused new or properly recertified steel 17-H DOT specification containers or equivalent as follows:

(a) First, the inner container having a capacity of 30 gallons or less shall have a water tight liner at least 4 mils thick hermetically sealed after filling.

(b) The biological material shall be thoroughly layered in the inner container in a ratio of thirty (30) parts biological material to at least one (1) part slaked lime and ten (10) parts absorbent, which shall be agricultural grade 4 vermiculite or medium grade diatomaceous earth, by volume. The addition of formaldehyde is strictly prohibited.

(c) The closure on the inner container shall be made with a 16-lug closing tool or standard lid with securely attached ring and bolt. Lever locks are not acceptable.

(d) The outer container, 55 gallon capacity for a 30 gallon inner container, shall be filled initially with at least 4 inches of absorbent material, specified in (b), the inner container in an upright position, and the remaining volume with the absorbent material; then securely closed and properly sealed.

(e) Containers of smaller capacity may be used provided that the volume of the outer container is at least 1.8 times the volume of the inner container.

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Site Construction and Maintenance Conditions

51. Construction of standard waste burial trenches shall be in accordance with Chem-Nuclear Systems, Inc. Trench Construction Details Drawing No. 500-101 Revision C approved on September 9, 1980, by David G. Ebenhack, Manager of Health and Safety, and the referenced procedures thereto. Any changes to these drawings, specifications, and procedures must have approval from the Department before implementation.

52. The licensee shall not begin construction of any trench prior to approval of the Department as to location, trench bottom elevation and intended use.

53. The licensee shall not initiate burial operations in newly excavated trenches until the Department has inspected and approved the trenches. An initial inspection will be made by the Department upon completion of excavation of the trench, sumps, french drain inside the trench, drainage ditches adjacent to the trench and installation of sumps and standpipes. An intermediate inspection will be made by the Department after the french drain and sumps have been filled with rock. A final inspection will be made by the Department upon completion of construction requirements per Trench Construction Details Drawing No. 500-101 Revision C.

54. Open trenches to include trenches under construction and partially filled trenches shall be protected to prevent runoff water from entering trenches. Radioactive waste shall not be placed into trench areas where water has accumulated. Burial of radioactive waste into trenches with unusual amounts of water shall immediately cease until corrective action has been taken and origin of water determined.

55. The licensee shall maintain a minimum of two feet of compacted clay between the last layer of waste and the surface of the ground. Backfilling shall commence immediately as waste reaches the proper elevation in the trench. Upon completion of burial operations in a burial trench, the licensee shall add an additional three feet minimum of earth on top of the two feet cover. Completed trenches shall at no time be used for stockpiling large volumes of earth not withstanding provisions for a final grading plan.

56. The licensee shall use proper surface water management techniques on the site to insure that:

    (a) Erosion is minimized.
    (b) Surface runoff is directed away from the trenches.
    (c) Accumulations of standing water are minimized.
    (d) Standing water in the immediate disposal area is prevented.

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Rev. Aug. 1973

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

Supplementary Sheet

License Number 097

Amendment No. 28

Site Construction......

57. All wells, sumps, Toner tubes, and other protrusions into the trench, except for the unused portion of the trench itself, shall be sufficiently capped or covered to prevent the introduction of extraneous material. All well pipes and sump pipes shall be protected from damage.

58. The licensee shall, at least monthly, perform an inspection of completed trenches to ascertain any erosion, settling, cracking, subsidence, or loss of ground cover grasses and make corrections immediately. Documentation of the inspection findings and all repairs even if the repairs were performed as a routine maintenance function shall be made and incorporated into a permanent record and submitted with the stabilization plan for final site closure.

59. Interim or final grades shall be established and seeding of trench covers shall commence at no more than one year following final trench burial operations.

60. The licensee shall use any reasonable means, including but not limited to fencing and security personnel, to prevent unauthorized entry into the restricted area of the site.

61. Temporary trench boundary markers and trench identification markers shall be erected upon completion of backfill operations until permanent granite markers are installed.

62. A series of granite markers, one at the end of each completed trench and on each corner, shall be installed upon completion of the seeding of trench covers. The following information shall be inscribed on the end monument, and this information shall be reported to the Chief, Bureau of Radiological Health, South Carolina Department of Health and Environmental Control, 2600 Bull Street, Columbia, South Carolina 29201:

   (a) Total activity of radioactive material in curies excluding source and special nuclear materials, total amount of source material in pounds, and total amount of special nuclear material in grams in the trench.

   (b) Date of completion of the burial operations; and,

   (c) Volume of waste in the trench.

63. The licensee shall not exhume previously buried waste.

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Burial Operation Conditions

64. Licensee personnel shall wear appropriate protective clothing, apparatus, and gloves at all times while handling or disposing of radioactive waste.

65. The licensee shall be a "Registered User" of all licensed casks delivered to the site containing radioactive waste for disposal.

66. At least one health physics technician shall be present during all waste handling, offloading and disposal operations.

67. The licensee shall maintain radiation levels at the edge of open trenches at or below 100mR/hr.

68. Uncovered waste shall not extend more than 100ft. beyond the backfilled portion of the trench.

69. The licensee shall bury containers of Krypton 85 and Xenon 133 gaseous radioactive materials in upright positions in the trench with a minimum spacing of ten (10)ft. between gas containers.

70. The licensee shall maintain the ability to identify and locate special nuclear material authorized for burial.

71. Unless otherwise prohibited by this license, the licensee may receive and bury packaged radioactive wastes containing more than 50 grams but not more than 350 grams of Uranium 235 in solid form and having a minimum volume of 7.5ft.^{3} under the following conditions:

    (a) Single packages or two packages separated by at least 8 inches of soil shall be buried at least 12ft. from any other packages containing special nuclear material.

    (b) Not more than 4 packages shall be placed in one vertical Toner tube. Single straight rows of Toner tubes, with center-to-center spacing of at least 3.5 feet, shall be separated in the trench at least 30 feet.

72. Unless specifically authorized, the licensee shall not store any package containing radioactive material, source material, or special nuclear material for a period greater than six months from the date of receipt of the package prior to burial.

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Amendment No. 28

Environmental Surveillance Conditions

73. The licensee shall conduct an on-site monitoring and environmental monitoring program capable of detecting the potential contribution of radioactive material from the site to the environment. The monitoring program shall be performed in accordance with Chem-Nuclear Systems, Inc. Environmental Surveillance Plan submitted October 31, 1980. Any changes to this plan shall be approved by the Department.

74. Should any samples taken from the trench monitoring wells, cluster wells, or air samples reveal increases in the concentration of radioactive material which were determined prior to commencement of the burial operations, the licensee shall perform further surveys to determine whether or not the increase is due to the land burial operations. The licensee shall notify the Chief, Bureau of Radiological Health, South Carolina Department of Health and Environmental Control, within 48 hours of any such increases.

75. The licensee shall submit results of all scheduled environmental sampling to the Department quarterly.

76. Monitoring wells in clusters will be placed outside the trenches but in the trench area. Specific locations shall be determined through consultation. The initial well of a cluster will be core drilled to the water table and a representative sample of the core shall be submitted to the Department. The depth and number of additional wells in the cluster are to be determined by the sand-clay composition observed in the initial core. All wells shall be grouted, sealed and capped.

Site Closure & Stabilization Conditions

77. As material buried may not be transferred by abandonment or otherwise, unless specifically authorized by the Department, the expiration date on this license applies only to the above ground activities and to authority to bury radioactive material wastes at the site specified in Condition 9. The license continues in effect and the responsibility and authority for possession of buried radioactive material wastes continues until the Department finds that the plan established for preparation of the Barnwell Site for transfer to another person has been satisfactorily implemented in a manner to reasonably assure protection of the public health and safety and the Department takes action to terminate your responsibility and authority under this license. All requirements for environmental monitoring, site inspection, and maintenance, and site security continue whether wastes are being buried or not.

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Site Closure....

78. The licensee shall develop a site closure and stabilization plan that addresses, as a minimum, the following performance objectives:

(a) Bury all waste in accordance with the requirements of the license.

(b) Dismantle, decontaminate, as required, and dispose of all structures, equipment, and materials that are not to be transferred to the Department.

(c) Document the arrangements and the status of the arrangements for orderly transfer of site control and for long term care by the government custodian. Also document the agreement, if any, of State or Federal governments to participate in, or accomplish, any performance objective. Specific funding arrangements to assure the availability of funds to complete the site closure and stabilization plan must be made.

(d) Direct gamma radiation from buried wastes should be essentially background.

(e) Demonstrate that the release of radionuclides through air and ground and surface water pathways are in compliance with Title A, RHA 3.5, "Concentrations in Effluents to Unrestricted Areas" at the site boundary and EPA drinking water limits of the nearest water supply.

(f) Render the site suitable for surface activities during custodial care. Planned custodial care may be limited to activities such as vegetation control, minor maintenance, and environmental monitoring. However use of the site surface for activities such as parking lots may be planned. Final conditions at the site must be acceptable to the Department and compatible with its plan for the site.

(g) Demonstrate that all trench elevations are above water table levels taking into account the complete history of seasonable fluctuations.

(h) Eliminate the potential for erosion or loss of site or trench integrity due to factors such as groundwater, surface water, wind, subsidence, and frost action. For example, an overall site surface water management system must be established for humid sites to drain rainwater and snowmelt away from the burial trenches. All slopes must be sufficiently gentle to prevent slumping or gullying. The surface must be stabilized with established short rooted grass, rock, riprap, or other measures. Trench caps must be stabilized so that erosion, settling, or slumping of caps does not occur.

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Site Closure.....

(i) Demonstrate that trench markers are in place, stable, and keyed to benchmarks. Identifying information must be clearly and permanently marked.

(j) Compile and transfer to the Department complete records of site maintenance and stabilization activities, trench elevation and locations (in USGS coordinates), trench inventories, and monitoring data for use during custodial care for unexpected corrective measures and data interpretation.

(k) Establish a buffer zone surrounding the site sufficient to provide space to stabilize slopes, incorporate surface water management features, assure that future excavations on adjoining areas would not compromise trench or site integrity, and provide working space for unexpected mitigating measures in the future. The buffer zone must also be transferred to the custodial agency. The width of the buffer zone will be determined on a site specific basis. The buffer zone may generally be less than 300 feet.

(l) Provide a secure passive site security system (e.g., a fence) that requires minimum maintenance.

(m) Stabilize the site in a manner to minimize environmental monitoring requirements for the long-term custodial phase and develop a monitoring program based on the stabilization plan.

(n) Investigate the causes of any statistical increases in environmental samples which have occurred during operation and stabilization. In particular, any evidence of unusual or unexpected rates or levels of radionuclide migration in or with the groundwater must be analyzed and corrective measures implemented.

(o) Eliminate the need for active water management measures, such as sump or trench pumping and treatment of the water to assure that wastes are not leached by standing water in the trenches. Passive systems are preferred. Engineered methods of intercepting contaminated groundwater or diverting groundwater should also be passive.

(p) Evaluate present and zoned activities on adjoining areas to determine their impact on the long-term performances of the site and take reasonable action to minimize the effects.

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79. A preliminary plan for preparation of the site for transfer to another person who would only passively hold the site shall be submitted for review. The plan shall be consistent with Condition 78 of this license and shall include demonstration that funds are being set aside or other measures being taken are adequate to finance the site closure plan. The plan shall also include preliminary estimates of costs, environmental impacts, data needs, personnel needs, material and equipment needs, planned documentation and quality assurance, and detailed plan for trench locations and elevations, expected capacities, planned surface contours, and buffer zones.

80. A reassessment of current operating practices shall be submitted. The reassessment shall consider the objectives of the site plan specified in Condition 79 and any changes in operation at the site which would enhance implementation of the plan.

81. The licensee shall submit an updated plan and operational assessment every five (5) years for review.

82. One year prior to the anticipated transfer of the site and buried radioactive materials to another person (including an agency of the U.S. Government) the licensee shall submit a final version of the site preparation plan including a schedule for implementation of all remaining plan elements prior to transfer, and a description of the mechanics of orderly transfer in coordination with the transferee.

Date of Issuance November 13, 1980

For The South Carolina Department of Health And Environmental Control

BY: Heyward G. Shealy

FORM RHA-L
Rev. Aug. 1973

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

Supplementary Sheet

License Number 097

Amendment No. 29

Chem-Nuclear Systems, Inc.
Barnwell Waste Management Facility
P.O. Box 726
Barnwell, South Carolina 29812

South Carolina Radioactive Material License No. 097 is hereby amended:

To Change:

Condition No. 71 to read as follows:

71. Unless otherwise prohibited by this license, the licensee may receive and bury packaged radioactive wastes containing more than 100 grams but not more than 350 grams of Uranium 235 in solid form and having a minimum volume of 7.5ft.^{3} under the following conditions:

(a) Single packages or two packages separated by at least 8 inches of soil shall be buried at least 12ft. from any other packages containing special nuclear material.

(b) Not more than 4 packages shall be placed in one vertical Toner tube. Single straight rows of Toner tubes with center-to-center spacing of at least 3.5 feet, shall be separated in the trench at least 30 feet.

Date of Issuance November 17, 1980

For The South Carolina Department
of Health And Environmental Control

BY: Heyward G. Shealy
Heyward G. Shealy, [illegible]
Division of Radiological Health

FORM RHA-L
Rev. Aug. 1973

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

Supplementary Sheet

License Number 097

Amendment No. 30

Chem-Nuclear Systems, Inc.
Barnwell Waste Management Facility
P.O. Box 726
Barnwell, South Carolina 29812

In accordance with letters dated February 20, 1981 and May 13, 1981, signed by David G. Ebenhack, Radioactive Material License No. 097 is hereby amended:

To Change:

Condition No. 26 to read as follows:

26. A. Unless otherwise specified in this license, the licensee shall not receive any liquid radioactive waste regardless of the chemical or physical form. Solidified radioactive waste shall have no detectable free standing liquids. For purposes of this condition, the terminology "no detectable free standing liquids" means one-half percent (0.5%) by waste volume of non-corrosive liquids per container.

B. In lieu of the requirements of paragraph A. above, solidified waste containing non-corrosive liquids in excess of one-half percent (0.5%) by waste volume, and less than one percent (1%) non-corrosive liquids by waste volume, may be received and disposed of in high integrity containers approved by the Department.

To Add:

Condition No. 83.

83. The licensee shall not receive or bury oil or lubricants in any physical form. However, this does not prohibit the receipt and disposal of waste containing incidental or trace amounts of oil which have been absorbed, provided that the amount of absorbed oil does not exceed one percent (1%) by waste volume in a container.

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SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
Supplementary Sheet

License Number 097

Amendment No. 30

To Add:

Condition 84.

84. The licensee shall not receive or bury any pyrophoric material or any material that may react violently with water or moisture.

Date of Issuance May 19, 1981

For The South Carolina Department
of Health And Environmental Control

BY: Heyward G. Shealy
Heyward G. Shealy, Chief
Bureau of Radiological Health

FORM RHA-L
Rev. Aug. 1973

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

Supplementary Sheet

License Number 097

Amendment No. 31

Chem-Nuclear Systems, Inc.
Barnwell Waste Management Facility
P.O. Box 726
Barnwell, South Carolina 29812

In accordance with letter dated July 20, 1981, signed by David G. Ebenhack, Radioactive Material License No. 097 is hereby amended:

To Change:

Condition 50.

Radioactive Biological Material Packaging Condition

50. Radioactive biological materials shall be doubly packaged in unused new or properly recertified steel 17-H DOT specification containers or equivalent as follows:

(a) First, the inner container having a capacity of 55 gallons or less shall have a water tight liner at least 4 mils thick hermetically sealed after filling.

(b) The biological material shall be thoroughly layered in the inner container in a ratio of thirty (30) parts biological material to at least one (1) part slaked lime and ten (10) parts absorbent, which shall be agricultural grade 4 vermiculite or medium grade diatomaceous earth, by volume. The addition of formaldehyde is strictly prohibited.

(c) The closure on the inner container shall be made with a 16-lug closing tool or standard lid with securely attached ring and bolt. Lever locks are not acceptable.

(d) The outer container, 55 gallon capacity for a 30 gallon inner container, or 83 gallon capacity for a 55 gallon inner container, shall be filled initially with at least 4 inches of absorbent material, specified in (b), the inner container in an upright position, and the remaining volume with the absorbent material; then securely closed and properly sealed.

(e) Containers of small capacity may be used provided that the volume of the outer container is at least 1.5 times the volume of the inner container.

Date of Issuance July 23, 1981

For The South Carolina Department of Health And Environmental Control

BY Heyward G. Shealy
Heyward G. Shealy, Chief
Bureau of Radiological Health

FORM RHA-L
Rev. Aug. 1973

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
Supplementary Sheet

License Number 097

Amendment No. 32

Chem-Nuclear Systems, Inc.
Barnwell Waste Management Facility
P.O. Box 726
Barnwell, South Carolina 29812

South Carolina Radioactive Material License No. 097 is hereby amended:

To Change:

Condition No. 48:

48. The licensee shall not receive shipments of radioactive materials unless appropriate lifting devices of sufficient length have been provided and securely attached to containers and palletized shipments within a cask.

Date of Issuance August 3, 1981

For The South Carolina Department of Health And Environmental Control
ORIGINAL SIGNED

BY: H. G. Shealy
Heyward G. Shealy, Chief
Bureau of Radiological Health

Appendix E

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL REGULATION NO. 61-83: TRANSPORTATION OF RADIOACTIVE WASTE INTO OR WITHIN SOUTH CAROLINA

South Carolina Department of Health

And Environmental Control

Regulation No. 61-83

Transportation of

Radioactive Waste Into or Within

South Carolina

Approved by the South Carolina

Board of Health and Environmental Control
November 13, 1980

Effective Date
May 22, 1981

Promulgated pursuant to Act No. 429 of 1980, The South Carolina Radioactive Waste Transportation and Disposal Act, Amending Section 13-7-10 et seq. of the 1976 Code of Laws, The South Carolina Atomic Energy and Radiation Control Act.

South Carolina
Department of Health and Environmental Control

Regulation 61-83

Transportation of Radioactive Waste
Into or Within South Carolina

Table of Contents

1. SCOPE

1.1 This regulation applies to any shipper, carrier or other person who transports radioactive waste into or within this State, to any persons involved in the generation of radioactive waste within this State, and to any shipper whose radioactive waste is transported into or within this State or is delivered, stored, or disposed of within this State.

1.2 All persons subject to the provisions of this regulation shall comply with all applicable provisions of 49 CFR Parts 171-179, 49 CFR Parts 386-399, 10 CFR Part 71, Regulation 61-63 of the 1976 Code of Laws of South Carolina, and any disposal facility radioactive material license requirements regarding the packaging, transportation, disposal, storage or delivery of radioactive materials.

2. DEFINITIONS

2.1 "Carrier" means any person transporting radioactive wastes into or within the State for storage, disposal or delivery.

2.2 "Department" means the Department of Health and Environmental Control including personnel authorized to act on behalf of the Department.

2.3 "Disposal facility" means any facility located within the State, which accepts radioactive waste for storage or disposal.

2.4 "Generation" means the act or process of producing radioactive wastes.

2.5 "Manifest" means the document used for identifying the quantity, composition, origin, and destination of radioactive waste during its transport to a disposal facility.

2.6 "Operator" means every person who drives or is in actual physical control of a vehicle transporting radioactive waste.

2.7 "Persons" means any individual, public or private corporation, political subdivision, government agency, municipality, industr partnership or any other entity whatsoever.

2.8 "Permit" means an authorization issued by the Department to any person involved in the generation of radioactive waste, to transport such radioactive wastes or offer such waste for transport.

2.9 "Radioactive waste" means any and all equipment or materials, including irradiated nuclear reactor fuel, which are radioactive or have radioactive contamination and which are required pursuant to any governing laws, regulations, or licenses to be disposed of as radioactive waste.

2.10 "Radiological violation" means radioactive contamination or the emission of radiation in excess of applicable limits.

2.11 "Shipper" means any person, whether a resident of South Carolin or a non-resident:

2.11.1 who transfers radioactive waste to a carrier for transportation into or within the State; or,

2.11.2 who transports his own radioactive waste into or within the State; or,

2.11.3 who transfers radioactive waste to another person if such wastes are transported into or within the State.

2.12 "Transport" means the movement of radioactive wastes into or within South Carolina.

3. PERMITS

3.1 Before any shipper transports or causes to be transported radioactive waste into or within the State of South Carolina, he shall purchase an annual radioactive waste transport permit from the Department. An application for a permit shall be submitted on Department Form RHA-200P "Application for Radicactive Waste Transport Permit" together with the necessary fee to: Chief, Bureau of Radiological Health, S.C. Department of Health and Environmental Control, 2600 Bull Street, Columbia, South Carolina, 20201.

3.2 Before a permit shall be issued, the shipper must deposit and maintain with the Department a cash or corporate surety bond in the amount of Five Hundred Thousand Dollars ($500,000.00); or, provide to the Department satisfactory evidence of liability insurance.

3.2.1 For purposes of this regulation, liability insurance shall mean coverage of Five Hundred Thousand Dollars ($500,000.00) per occurrence and One Million Dollars ($1,000,000.00) aggregate, or as otherwise provided by State law.

3.2.2 Any insurance carried pursuant to Section 2210 of Title 42 of the United States Code and Part 140 of Title 10 of the Code of Federal Regulations shall be sufficient to meet the requirements of this section.

3.2.3 Liability insurance shall be specific to the packaging, transportation, disposal, storage and delivery of radioactive waste.

3.2.4 Shippers maintaining liability insurance for the purpose of this regulation may provide to the Department a certificate of insurance from their insurer indicating the policy number, limits of liability, policy date and specific coverage for packaging, transportation, disposal, storage and delivery of radioactive materials.

3.2.5 A cash or corporate surety bond previously posted will be returned to the shipper upon notification to the

Department in writing of his intention to cease shipments of radioactive waste into or within the State. Such bond will be returned after the last such shipment is accepted safely at its destination.

3.3 Each permit application shall include a certification to the Department that the shipper will comply fully with all applicabl State or Federal laws, administrative rules and regulations, licenses, or license conditions of the disposal facility regardi the packaging, transportation, storage, disposal and delivery of radioactive wastes.

3.4 Each permit application shall include a certification that the shipper will hold the State of South Carolina harmless for all claims, actions, or proceedings in law or equity arising out of radiological injury or damage to persons or property occuring during the transportation of its radioactive waste into or within the State including all costs of defending the same; <u>provided</u>, however, that nothing contained herein shall be construed as a waiver of the State's sovereign immunity; and, <u>further provided</u>, that agencies of the State of South Carolina shall not be subject to the requirements of this provision.

3.5 Permit fees will be annually determined and assessed by the Department based on the following classifications:

3.5.1 Class X - more than an annual total of 75 cubic feet or more than 100 curies of radioactive waste for disposal within the State.

3.5.2 Class Y - an annual total of 75 cubic feet or less of radioactive waste consisting of 100 curies or less total activity for disposal within the State.

3.5.3 Class Z - any shipment of radioactive waste which is not consigned for storage or disposal within the State, but which is transported into or within the State.

3.6 Permits will be valid from the date of issuance through December 31 of each calendar year. Permit fees are not refundable. Permits may be renewed by filing a new application with the Department.

4. SHIPPER'S REQUIREMENTS

4.1 Before any shipment of radioactive waste may be transported into or within the State, the shipper shall give written notice to the Department not less than 72 hours nor more than 30 days before the expected date of arrival of the shipment or departure from the shipper's facility within the State as the case may be, except as provided in paragraph 4.1.3.

4.1.1 All prior notifications shall be filed on a Department form designated as RHA-PNC "Radioactive Waste Shipment Prior Notification and Manifest Form."

4.1.2 The shipper shall immediately notify the Department of any cancellations or significant changes in the prior notification or manifest summary which may occur prior to the shipment departing his facility. For example, such changes include changes in date of arrival, carrier, route, waste description, curie content, volume, or waste classification.

4.1.3 For shipments consisting of 75 cubic feet or less containing one curie of radioactive material or less which may be consigned as non-exclusive use shipments according to applicable U.S. Department of Transportation regulations, the requirement for prior notification contained in paragraph 4.1 is waived. Such shipments must otherwise comply with all other applicable requirements regarding the packaging, transportation, storage, disposal and delivery of radioactive wastes.

4.2 The shipper shall provide to the carrier with each separate shipment a copy of the RHA-PNC "Radioactive Waste Shipment Prior Notification and Manifest Form" required by paragraph 4.1. Such copy shall show any changes made pursuant to paragraph 4.1.2 above. Each shipper shall instruct the carrier to comply with the route and schedule contained therein.

4.3 The manifest accompanying each shipment of radioactive waste shall include a copy of the shipper's certification prepared on Department form RHA-CT, Part I, "Radioactive Waste Shipment Certification Form," which shall include certification that the shipment has been inspected and complies with all applicable State and Federal laws and administrative rules and regulations license or license conditions of the disposal facility regardin the packaging, transportation, storage, disposal and delivery of radioactive wastes.

4.4 Following acceptance of each separate shipment at a disposal facility or at the consignee's facility, it shall be the responsibility of each shipper to provide to the Department for such shipment a copy of Department form RHA-PNC "Radioactive Waste Prior Notification and Manifest Form" with the Consignee Acknowledgement properly executed and to provide the Department with the "Radioactive Waste Shipment Certification Form," Depar ment form RHA-CT, which accompanied that shipment.

5. CARRIER REQUIREMENTS

5.1 For each shipment of radioactive waste materials shipped into or within the State, a carrier shall complete Part II: Carrier's Certification on the form RHA-CT provided by the shipper. The certificate shall be signed by a principal, officer, partner, responsible employee or other authorized agent of the carrier.

5.1.1 The carrier shall certify that the shipment is properly placarded for transport and that all shipping papers required by law and administrative rules and regulations have been properly executed; and,

5.1.2 that the transport vehicle has been inspected and meets the applicable requirements of the Federal government and the State of South Carolina, and that all safety and operational components are in good operative condition; and,

5.1.3 that the carrier has received a copy of the shipper's "Radioactive Waste Prior Notification and Manifest Form," specified in paragraph 4.2 and the "Radioactive Waste Shipment Certification Form," form RHA-CT specified in paragrah 4.3; and,

5.1.4 that the carrier shall comply fully with all applicable laws and administrative rules and regulations, both State and Federal, regarding the transportation of such waste.

5.2 A carrier shall immediately notify the Department of any variance, occurring after departure, from the primary route and estimated date of arrival of shipment as provided by the shipper on Form RHA-PNC.

5.3 The copies of Forms RHA-CT and RHA-PNC shall accompany the shipment to the destination and shall be presented together with the manifest and other shipping papers.

6. DISPOSAL FACILITY OPERATOR

6.1 Owners and operators of disposal facilities shall permanently record, and report to the Department within twenty-four (24) hours after discovery, all conditions in violation of the requirements of this regulation discovered as a result of inspections required by any license under which the facility is operated.

6.2 Prior to the receipt of radioactive wastes at a disposal facility in this State, the owners and operators of such facility shall notify each shipper of any special requirements, if any, in effect regarding the packaging, transportation, storage, disposal or delivery of such wastes at that facility.

6.3 No owner or operator of a disposal facility located within this State shall accept radioactive waste for storage or disposal unless the shipper of such waste has a valid, unsuspen permit issued pursuant to this regulation.

7. PENALTIES

7.1 Any person who commits a radiological violation shall:

7.1.1 be fined not less that One Thousand Dollars ($1,000.00) nor more than Five Thousand Dollars ($5,000.00); and,

7.1.2 if such person is a shipper, have his permit suspended for a period of not less than thirty (30) days and until such time as he demonstrates to the Department's satisfaction that adequate measures have been taken to prevent reoccurrence of the violation.

7.2 Any person who commits a second radiological violation within twelve (12) months of the first such violation shall:

7.2.1 be fined not less than Five Thousand ($5,000.00) nor more than Twenty-five Thousand Dollars ($25,000.00); and,

7.2.2 if such person is a shipper, have his permit suspended for a period of not more than one year and until such time as he demonstrates to the satisfaction of the Department that adequate measures have been taken to prevent reoccurrence of the violations.

7.3 Any person who commits a non-radiological violation of the provisions of this regulation shall be fined not more than One Thousand Dollars ($1,000.00) for each violation; provided, that should the Department determine that a series of such violations has occurred, the Department shall suspend or revoke that person's permit for a period of not more than twelve (12) months.

7.4 Any person to whom an order, injunction, suspension, or fine issued under this article is directed shall comply therewith immediately, but on application to the Department, within twenty (20) days after the date of the order, shall be afforded a hearing within thirty (30) days of such application.

8. SEVERABILITY CLAUSE

8.1 It is hereby declared that each of the sections and provisions of this regulation are severable, and in the event that any one or more of such sections are declared unconstitutional or invali the remaining sections and provisions of this regulation shall remain in effect.

Form RHA-200P
(10/80)

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
APPLICATION FOR RADIOACTIVE WASTE TRANSPORT PERMIT

Instructions: Complete Items 1 through 8. Submit original and one copy to Chief, Bureau of Radiological Health, S.C. Dept. of Health and Environmental Control, 2600 Bull Street, Columbia, S.C. 29201. All copies must be signed and dated. Additional sheets may be used if necessary. Upon approval, the Department will return one copy with your transport permit. All permit fees should be made payable to the S.C. Dept. of Health and Environmental Control, Bureau of Finance, 2600 Bull Street, Columbia, S.C. 29201. Please note on remittance, "For Radioactive Waste Transport Permit."

Note: Radioactive Waste Transport Permits may be purchased for more than one facility or location of a company, corporation, etc. However, an application shall be submitted for each facility to include the additional fee and the required certificate of insurance or bond.

1. Name and Address of Applicant (Shipper):	2. Person responsible for Radioactive Waste shipment: (a) Name: (b) Title: (c) Address: (d) Telephone:
3. Locations from which waste will be shipped if application is for more than one facility. (a) (b)	4. NRC or Agreement State Radioactive Material License No. for each location. (a) (b)
5. Estimated Annual Cubic Footage.	6. Amount of permit fee remitted.

Information to be Submitted as Attachment

7. A Certificate of Liability Insurance shall be submitted as evidence of financial ability to protect the State of South Carolina and the public at large from possible radiological injury or damage due to packaging, transportation, disposal, storage, or delivery of radioactive waste. For those applicants not maintaining liability insurance, they must deposit and maintain with the Department a cash or corporate surety bond in the amount of Five Hundred Thousand Dollars ($500,000.00).

CERTIFICATE

8. In compliance with Act No. 429 of 1980, the South Carolina Radioactive Waste Transportation and Disposal Act, I hereby certify on behalf of the above-named applicant (shipper) to the South Carolina Department of Health and Environmental Control that: (A) the above-named applicant (shipper) will comply fully with all applicable laws and administrative rules and regulations, both State and Federal, and any disposal facility radioactive material license requirements regarding the packaging, transportation, storage, disposal, and delivery of such wastes; (B) the above-named applicant (shipper) will hold the State of South Carolina harmless for all claims, actions, proceedings in law or equity arising out of radiological injury or damages to persons or property occuring during the transportation of its radioactive waste into or within the State including all costs defending same; provided, however, that nothing contained herein shall be construed as a waiver of the State's sovereign immunity; (C) the above-named applicant (shipper) has current copies of the Regulations for the Transportation of Radioactive Waste into or within the State of South Carolina, DOT Regulations 49 CFR Parts 171-179, and when applicable, the disposal site radioactive material license and the disposal site waste acceptance criteria; (D) the above-named applicant (shipper) has prepared this application to conform with South Carolina Department of Health and Environmental Control Regulation for Transportation of Radioactive Waste Into or Within South Carolina, and that all information contained herein, including any required supplements attached hereto, is true and correct to the best of my knowledge and belief.

Date____________________

____
Typed Name and Title of Agent of Applicant (Shipper)

____
Signature

DHEC 800
(10/80) Revision

Form RHA-PNC
(5/80)

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTRL
Radioactive Waste Shipment Prior Notification and Manifest Form

See Reverse Side for Instructions

1. Name and Address of Shipper:	2. Person Responsible for Radioactive Waste Shipment: (a) Name (b) Title (c) Telephone No. ( )
3. Radioactive Waste Transport Permit No.	4. Shipment Identification No.:
5. Location from which waste will be shipped:	6. Name and Address of Consignee
7. Scheduled Date of Departure of Shipment:	8. Estimated Date of Arrival of Shipment:

9. Carrier:	10. Type of Transport Vehicle:	11. Trailer No. and Owner (if available)

12. Routes shipment will follow in State of South Carolina (Be Specific):

Manifest Summary

13. Type Container or Cask:	14. Container Spec.	15. Total No. of Containers

16. Waste Description; Physical and Chemical Form	17. Prominent Radionuclides:

18. Total Curies:	19. Transport Group:	20. Total Cubic Feet:

21. Waste Classification:

		Normal Form	Special Form	Fissile
[] Radioactive LSA	[] Bulk LSA			
[] Radioactive LSA greater than Type A quantities	[] Limited quantities and radioactive devices	[] Type A quantity	[] Type A quantity	[] Class I
		[] Type B quantity	[] Type B quantity	[] Class II
		[] Large quantity	[] Large quantity	[] Class III

CERTIFICATION

I hereby certify on behalf of the above-named shipper to the South Carolina Department of Health and Environmental Control that the information provided herein is complete and correct to the best of my knowledge; and that the shipper has complied with all the provisions as required by Act No. 499 of 1980, the South Carolina Radioactive Waste Transportation and Disposal Act.

Date____________________

Typed Name and Title of Agent of Shipper

Signature

CONSIGNEE ACKNOWLEDGEMENT

This acknowledges to the South Carolina Department of Health and Environmental Control that the above-described radioactive waste shipment was received.

Date of Delivery

Signature of Consignee or authorized Agent

Typed or Printed Name and Title

DHEC 802
(5/80)

(Copies of this form may be reproduced locally as needed)

Form RHA-CT
(5/80)

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
Radioactive Waste Shipment Certification Form

General Instructions and Information: This is a two part form to be used by shippers and carriers of radioactive waste. The certifications contained herein satisfy the requirements of Section 13-7-150, of Act No. 499 of 1980, the South Carolina Radioactive Waste Transportation and Disposal Act. This certification along with a copy of the prior notification form shall accompany each shipment of radioactive waste into and within the State of South Carolina. The shipper is to complete his portion of the form and present it to the carrier as part of the shipping documents. Upon receipt, the carrier shall complete his portion of the form. Upon delivery of the shipment to the consignee, a copy of this certification form, and a copy of the Prior Notification and Manifest form with the consignee acknowledgement, shall be returned to the Department.

Part I: Shipper's Certificate of Compliance

1. Name of Shipper and Address:	2. Shipment Identification No.
Telephone No. ( )	3. Transport Permit No.

In compliance with Act No. 499 of 1980, the South Carolina Radioactive Waste Transportation and Disposal Act, I hereby certify on behalf of the above-named shipper to the South Carolina Department of Health and Environmental Control that the above-named shipper has complied with all provisions of Act No. 499 of 1980, and all applicable laws and administrative rules and regulations, both State and Federal, regarding the packaging, transportation, storage, disposal and delivery of such wastes. I further certify that this shipment of radioactive waste has been inspected within 48 hours of the time of departure and that no items of non-compliance with applicable laws, rules or regulations were found.

Date ______________________________

______________________________ ______________________________
Typed Name and Title of Agent of Shipper Signature

Part II: Carrier's Certification

1. Name of Carrier and Address:	2. Shipment Identification No.
Telephone No. ( )	3. Transport Trailer No.
4. Scheduled Date of Departure of Shipment:	5. Estimated Date of Arrival of Shipment:

Certification is hereby made to the South Carolina Department of Health and Environmental Control that: (a) the shipper has provided the carrier with a copy of the shipment manifest, the certificate of compliance, and the routing instructions; (b) the shipment of radioactive waste has been properly placarded for transport according to applicable U.S. Department of Transportation Regulations; (c) all shipping papers originated or reproduced by the carrier have been properly executed; (d) the transport vehicle has been inspected according to applicable State and Federal regulations within the prescribed intervals and that all safety and operational components are in good working order and meet the requirements of regulations; (e) all drivers who will operate the vehicle within the State of South Carolina are qualified to transport hazardous materials as specified by applicable U.S. Department of Transportation regulations; (f) the Department shall be immediately notified of any variance, occuring after departure, from the shipper's notification of primary routes in South Carolina and estimated date of arrival; (g) all applicable laws and administrative rules and regulations, both State and Federal, regarding the transportation of radioactive wastes will be complied with.

Date ______________________________

______________________________ ______________________________
Typed or Printed Name and Title Signature

DHEC 803
(5/80) (Copies of this form may be reproduced locally as needed)

General Instructions and Information

1. This form is to be used to provide the Department with prior notification of radioactive waste shipments transported into or within the State of South Carolina. This notification is to be made 72 hours before the expected date of arrival in the State. All written notices should be mailed to:

   Bureau of Radiological Health
   Radioactive Waste Management Section
   S.C. Dept. of Health and Environmental Control
   2600 Bull Street
   Columbia, South Carolina 29201

2. A separate form shall be submitted for each radioactive waste shipment.

3. Prior notification is required of all radioactive waste shipments as defined in paragraph 2 of Interim Regulations for the Transportation of Radioactive Waste into or within South Carolina except as provided in paragraph 4.1.2 of the Regulation.

4. The "Manifest Summary" portion of this form will satisfy requirements of providing the Department with a shipping manifest, however, it does not satisfy the requirements of shipping documents which shall accompany the shipments as required by DOT Regulations and the disposal facility's license and criteria.

5. A copy of this completed form shall be provided to the carrier and all drivers of the radioactive waste shipment.

6. Upon delivery of the shipment to the consignee, acknowledgement of receipt shall be obtained, and a copy of this form and the shipper/carrier's certification form shall be returned to the Department.

Specific Instructions

Item Number

1. Self Explanatory
2. Self Explanatory
3. This item applies to all shipments of radioactive waste transported to and within the State of South Carolina.
4. Each shipment of radioactive waste shall be identified in some manner by the shipper. This number can be a radioactive shipment record number, bill of lading number, allocation number, etc. The identification number shall only be used once to identify the one shipment for which notification is being made.
5. Self Explanatory
6. Indicate in this item the disposal facility, company, organization, etc., to which this shipment has been consigned.
7. Self Explanatory
8. For through shipments, indicate in this item estimated date shipment will pass through the state.
9. Self Explanatory

10.& 11. Applies only to exclusive use, sole use, and full load shipments.

12. All routing information must be specific. You should check with carrier to insure routes you prescribe are appropriate. The carrier is responsible to inform the Department of any changes of routes in South Carolina after departure.

13 thru 21. Self Explanatory

Certification: To be signed only by an authorized representative or agent of the shipper and carrier.

Appendix F

TRUST AGREEMENT

STATE OF SOUTH CAROLINA   TRUST AGREEMENT

TRUST AGREEMENT, made this 24 day of March 1981 between CHEM-NUCLEAR SYSTEMS, INC., a corporation organized and existing under the laws of the State of Washington, hereinafter called the "GRANTOR", and the Treasurer of the State of South Carolina, hereinafter called the "TRUSTEE", together with the Budget and Control Board for the State of South Carolina, designated herein as "BENEFICIARY"; and

WHEREAS, the "GRANTOR" operates its business of providing for the disposal of low-level radioactive waste pursuant to South Carolina Radioactive Materials License No. 097 issued by the South Carolina Department of Health and Environmental Control; and

WHEREAS, pursuant to the terms of such license, it is required that the "GRANTOR" herein establish a Site Stabilization and Closure Plan which, inter alia, includes a decommissioning plan satisfactory to the Department of Health and Environmental Control and approved by the State Budget and Control Board to provide reasonable assurances of adequate funds for use in decommissioning the licensed radioactive waste disposal site situate in Barnwell County, South Carolina, at the cessation of normal business operations or at the termination of the aforementioned license, whichever first occurs; and

WHEREAS, the "GRANTOR" in order to assure adequate funding for decommissioning, and in compliance with the terms of its license, by the creation of this Trust Agreement places certain funds in trust for that public purpose and by the execution of this Trust Agreement is bound to the terms and conditions hereof; and

WHEREAS, the "TRUSTEE", for its fee, herein agrees to serve in its capacity and be bound by the terms hereof; and

WHEREAS, the Budget and Control Board of the State of South Carolina is designated as "BENEFICIARY" hereto with respect to its duties, as provided by law.

NOW, THEREFORE, the parties hereto agree as follows:

1. "GRANTOR" hereby assigns and delivers to "TRUSTEE", in trust, one million seven hundred twenty-six thousand seven hundred dollars and thirty cents ($1,726,700.30), receipt of which is hereby acknowledged by "TRUSTEE". Such monies, and any additional monies or other property which may subsequently be added thereto, from time to time, which additional monies or other property are determined by the South Carolina Department of Health and Environmental Control to be adequate to carry out the purposes of the Site Stabilization and Closure Plan, as amended, shall constitute the trust estate and shall be held in trust solely for the uses and purposes and upon the terms and conditions of the trust herein provided.

2. "GRANTOR" may hereafter, from time to time, pay or deliver additional sums of money or other property to "TRUSTEE" to be held, invested, and distributed by "TRUSTEE" as an addition to the trust estate, in all respects, as is herein provided.

3. The principal of this trust shall, at all times except as specifically provided herein, be maintained separately from any income derived from investing said principal and shall be accounted for separately and said principal funds shall be designated as the "Principal Account".

4. All income generated by investments of said principal shall be held in an "Income Account," separately from the established "Principal Account," except as is hereinafter provided in paragraph No. 6. The "TRUSTEE" shall provide "GRANTOR" and "BENEFICIARY" with an annual accounting of both the "Principal Account" and the "Income Account", and shall not, under any circumstances, commingle the Principal and Income Accounts of the trust estate herein provided with any other funds under "TRUSTEE'S" control or in "TRUSTEE'S" possession.

5. The trust estate herein established, or any part thereof, shall be distributed to the "GRANTOR" or other person designated by the Budget and Control Board of the State of South Carolina for the sole purpose of site decommissioning only upon receipt by the "TRUSTEE" of written authorization from an authorized representative

of the State Budget and Control Board, directing such distribution to "GRANTOR" or such other person of a specified portion of the trust estate.

6. The net income from the trust estate shall be applied first to the payment of administrative expenses of the trust, including, but not limited to, taxes, special assessments, and trustee's commissions and expenses, and accumulated and reinvested as herein directed or permitted, and thereafter at a time suitable to "TRUSTEE", but not later than July 1 of each year, the remainder of the "Income Account" shall be transferred to the "Principal Acccount" as additional principal.

7. In the management, care and disposition of the trust assets, the "TRUSTEE" and his successors in office shall have all powers granted by the laws of the State of South Carolina, except as may be limited as herein provided, as well as the power to execute such instruments as they may deem necessary or proper, including, but not limited to, the following powers, all of which may be exercised without order of or report to any court:

(a) As to the Principal and Income Accounts, notwithstanding anything to the contrary contained herein, only the "TRUSTEE" is authorized to invest and reinvest the trust assets held in the accounts and then only in direct obligations of the United States Government, United States Government guaranteed agencies, obligations of the Federal Farm Credit Bank, Federal Home Loan Bank, Federal National Mortgage Assocation, general obligation bonds or notes of any State having a AAA credit rating as established by two nationally recognized credit rating services, or any other investments as approved both by the "GRANTOR" and the State Budget and Control Board according to an attached Schedule of Approved Securities, which schedule may be amended from time to time by written agreement of "GRANTOR" and the State Budget and Control Board, and the "TRUSTEE" shall account annually to the "GRANTOR" and the State Budget and Control Board of such investments of the Principal and Income Accounts.

(b) The "TRUSTEE" shall receive as compensation for his services hereunder such amounts as shall become due from time to time in accordance with the attached Schedule "A", or such fee as is mutually agreeable with "GRANTOR" and the State Budget and Control Board. Any successor trustee shall be compensated in like manner. It is further understood and agreed that the "TRUSTEE'S" fee will be paid only from the "Income Account" and that no part of said fee shall be borne by the "Principal Account".

8. In the event of the failure of the "TRUSTEE" to perform its duties hereunder for any reason, the "GRANTOR" and the State Budget and Control Board may by mutual agreement and consent in writing appoint a successor trustee to carry out the provisions of this Agreement. In the event that "GRANTOR" and the State Budget and Control Board cannot agree as to the appointment of a successor trustee, either party may apply to the Court of Common Pleas for Richland County for the appointment of such trustee. Such successor trustee shall be compensated in the manner set forth above in paragraph 7(b) and shall have all the powers, rights, obligations, duties, and immunities herein granted to the original trustee.

9. All the powers, rights, discretions, obligations, and immunities given to "TRUSTEE" by this agreement shall continue after termination of the trust created hereby until "TRUSTEE" shall have made actual and total distribution of all monies and other property held by him hereunder.

10. This public trust shall cease and terminate whenever the purpose thereof has been accomplished through the complete decommissioning of the site as evidenced by a written statement to that effect from the State Budget and Control Board and upon recommendation of the South Carolina Department of Health and Environmental Control, but otherwise may be terminated by the mutual consent of the "GRANTOR" and the State Budget and Control Board at any time prior thereto only upon written notice of termination from both "GRANTOR" and the State Budget and Control Board to "TRUSTEE" not less than thirty (30) days prior to such termination, and in such event the "Principal Account", "Income Account", and any undistributed income

will be distributed according to the mutual agreement and direction of both the "GRANTOR" and the State Budget and Control Board.

11. It is further understood and agreed that at the termination of this trust or in the event that this trust is, by mutual agreement, terminated and decommissioning is complete, then and in such event, subject to the prior written approval of the State Budget and Control Board, all principal balances remaining in the Principal and Income Accounts shall then be paid to "GRANTOR".

12. A final accounting will be made to both "GRANTOR" and the State Budget and Control Board at the termination of this Trust Agreement or upon the termination of this Trust Agreement by mutual consent of "GRANTOR" and the State Budget and Control Board or upon the withdrawal, removal or inability to perform of any trustee herein.

13. No bond shall be required of "TRUSTEE" hereunder, or of any successor trustee, unless such bond is required by the Budget and Control Board of the State of South Carolina. If such bond be required by the State Budget and Control Board, the cost thereof to "TRUSTEE" shall be borne by the Income Account.

14. In the event that the trust estate is found by the State Department of Health and Environmental Control to be insufficient to provide adequate funds to carry out the provisions of the Site Stabilization and Closure Plan, as amended, "GRANTOR" may provide such additional funds as may be required by the Department of Health and Environmental Control by adding same to the trust estate. Such additional funds may be in the form of cash, or may consist of securities or other property as may be found to be suitable and acceptable for such purpose as determined by "BENEFICIARY". Such additional funds may be added to the trust estate by written addenda and amendments to this trust and trust agreement, but this trust agreement shall not be construed as preventing "GRANTOR" from posting a bond or other surety acceptable to the Budget and Control Board to provide such additional funds for the purpose of carrying out the Site Stabilization and Closure Plan in the event that this trust is insufficient to provide for such site stabilization, closure, and decommissioning.

15. This agreement and the dispositions hereunder are made under and shall be construed and regulated, and their validity and effect shall be determined, in accordance with the laws of the State of South Carolina as such laws may from time to time exist. By executing this agreement, "GRANTOR" agrees to submit itself to the jurisdiction of the courts of the State of South Carolina for all matters arising or to arise hereunder, including, but not limited to, performance of said agreement and the payment of all licenses and taxes of whatever kind or nature applicable thereto.

16. This trust shall be irrevocable and shall not be altered, amended, revoked, or terminated by "GRANTOR" or any other person, except as may be provided herein.

17. If any provision of this agreement shall be invalid or unenforceable, the remaining provisions hereof shall continue to be fully effective.

IN WITNESS WHEREOF, the parties have hereunto set their hands and seals, in duplicate, this 24 day of March, 1981.

Signed, sealed and delivered in the presence of:

Barbara F. Hood
Donna J. Renaux

CHEM-NUCLEAR SYSTEMS INC.
GRANTOR

By: [signature] (L.S.)

[signature]
[signature]

TREASURER OF THE STATE OF
SOUTH CAROLINA
TRUSTEE

By [signature] (L.S.)

J.S. Hooks
Katherine M. Clarke

STATE BUDGET AND CONTROL
BOARD OF SOUTH CAROLINA
BENEFICIARY

By Richard W. Riley (L.S.)
GOVERNOR

STATE OF WASHINGTON)
COUNTY OF KING)

PERSONALLY appeared before me Barbara A. Davis and made oath that she saw the within named Chem-Nuclear Systems, Inc., by Bruce W. Johnson, its President, sign, seal, and as the act and deed of the said Corporation, deliver the written Trust Agreement and, that she with Donna J. Renaux witnessed the execution thereof.

Barbara A. Davis

SWORN to before me, this 24th
day of [illegible], 1981.

[illegible]
Notary Public for Washington
My Commission Expires [illegible], [illegible]

STATE OF SOUTH CAROLINA)
COUNTY OF RICHLAND)

PERSONALLY, appeared before me [illegible] and made oath that she saw the within named Treasurer of the State of South Carolina by the Honorable Grady L. Patterson, Jr., sign, seal, and as the act and deed of the Trustee, deliver the within Trust Agreement and that she with [illegible] witnessed the execution thereof.

[illegible]

SWORN to before me, this 2nd
day of [illegible], 1981.

[illegible]
Notary Public for South Carolina
My Commission Expires [illegible], [illegible]

STATE OF SOUTH CAROLINA)
)
COUNTY OF RICHLAND)

PERSONALLY, appeared before me Katherine N. Clarke and made oath that she saw the within named State Budget and Control of South Carolina by the Honorable Richard W. Riley, Governor of South Carolina, sign, seal, and as the act and deed of the Beneficiary, deliver the within Trust Agreement and that she with J. S. Hooks witnessed the execution thereof.

Katherine N Clarke

SWORN to before me, this 1st day of April, 1981.

Grace Ingram
Notary Public for South Carolina

My Commission Expires March 18, 1987

SCHEDULE OF APPROVED SECURITIES

Pursuant to the provisions of paragraph 7(a) of the attached Trust Agreement, Trustee is authorized to invest and reinvest the trust assets held by it pursuant to the Agreement only in the securities specified as follows:

1. Direct obligations of the United States Government;

2. Direct obligations of the United States Government guaranteed agencies;

3. Obligations of the Federal Farm Credit Bank;

4. Obligations of the Federal Home Loan Bank;

5. Obligations of the Federal National Mortgage Association;

6. Repurchase agreements secured by any of the above-referenced securities;

7. General obligation bonds or notes of any State having a AAA credit rating as established by two nationally recognized credit rating services; or

8. Any other investments as approved both by the "Grantor" and the State Budget and Control Board.

SCHEDULE "A"

Pursuant to the provisions of paragraph 7(b) of the attached Trust Agreement, Trustee's compensation for the usual services rendered as trustee shall be as designated below:

> 3/10 of 1% of the balance in the Principal and Income Accounts on the first anniversary of this Trust Agreement and on each anniversary thereafter.

Appendix G

LEASE AGREEMENT AND SUBSEQUENT AMENDMENTS

RECEIVED

OCT 24 1979

S. C. Dept. of Health and Environmental Control

STATE OF SOUTH CAROLINA)
)
COUNTY OF BARNWELL)

AMENDMENT TO LEASE AGREEMENT

WHEREAS, the Lessor, the State of South Carolina, acting through the State Budget and Control Board, and the Lessee, Chem-Nuclear Systems, Inc., entered into a lease agreement dated April 6, 1976; and,

WHEREAS, according to the terms and conditions of said lease agreement as contained in Paragraph 7 therein, certain payments being made by the Lessee to the Lessor at quarterly intervals were to be increased at the end of a three-year period of time according to the terms and conditions of Paragraph 7; and,

WHEREAS, the parties recognize that such re-negotiation in accordance with the terms and conditions of Paragraph 7 are impractical and not in the best interest of the parties; and,

WHEREAS, it is the desire and intention of the parties to amend the lease agreement with reference to Paragraph 7 and Paragraph 8 of the original lease agreement dated April 6, 1976, as hereinafter set forth.

NOW, THEREFORE, in consideration of the payments reserved herein and the mutual covenants made by the parties, Paragraph 7 and Paragraph 8 of the aforementioned lease agreement dated April 6, 1976, are amended as hereinafter set forth, to wit:

7. The Lessee understands that the storage and burial of radioactive waste requires perpetual surveillance and maintenance, and so long as it occupies the Site, the Lessee will undertake all surveillance and maintenance as required by all applicable laws, regulations, and licensing requirements for the protection of the public health and safety. The Lessee further understands that if for any reason at any time it should default, or fail to comply with the terms of its license, or for any reason withdraw from the premises, the Lessor would be required to assume surveillance and maintenance obligations and pay the surveillance and maintenance costs. The Lessee, therefore,

covenants and agrees to pay to the Lessor, at quarterly intervals, the sum of 55 cents for each cubic foot of radioactive waste buried at the Site during the period from September 1, 1979, through April 5, 1980. Payments shall be made at quarterly intervals at the rate of 75 cents per cubic foot of radioactive waste buried at the Site during the period from April 6, 1980, through April 5, 1981, and at the rate of one ($1.00) dollar per cubic foot from April 6, 1981, through April 5, 1982.

The rate of payment shall be re-negotiated by the parties to be effective April 6, 1982, with negotiations to begin not later than January 6, 1982. In the event the parties have not concluded such re-negotiations prior to March 6, 1982, Lessor, at its option, shall have the right upon written notice to Lessee to require the Lessee to make payments at a rate not to exceed two ($2.00) dollars per cubic foot from April 6, 1982, until the consummation of negotiations; provided, however, should the re-negotiated rate be less than the rate required to be paid based upon the exercise of Lessor's option then such difference shall be credited to the account of the Lessee. In the event the re-negotiated rate exceeds the rate required to be paid based upon the exercise of Lessor's option, Lessee shall not be required to pay such excess until the effective date of the re-negotiated rate, but in no event later than July 1, 1982.

The parties expressly agree that the escrow fund for perpetual care of the waste buried at the Site established by the parties pursuant to an agreement dated April 21, 1971, and continued pursuant to the lease dated April 6, 1976, shall continue to be maintained and the payments made pursuant hereto shall be added to such fund. Interest earned upon said fund for perpetual care shall accrue to the fund.

In order for the Lessor to determine the accuracy of payments by the Lessee, the Lessor shall have access to and the right to examine any pertinent books, documents, papers, accounts and records of the Lessee involving operations on the leased premises. Lessee agrees to surrender all receipt and burial records to Lessor five (5) years after the ending of the fiscal or calendar year to which the records pertain or within one (1) year after vacating the Site. Surrendered records will be made available at the request of the Lessee.

The parties further agree that upon expiration or earlier termination of this lease, all materials buried at the Site prior to such expiration or termination shall remain so buried and shall be thereupon owned by and become the sole and exclusive responsibility of Lessor, its successors or assigns.

8. The Lessee will not, without the Lessor's written consent, violate any of the terms and conditions of this lease; will not violate the terms of authorizing licenses issued by the South Carolina Department of Health and Environmental Control, the Nuclear Regulatory Commission or any other appropriate authority; will not use any part of the leased premises in a manner not in compliance with the covenants and purposes of this lease; and will not fail to comply with any applicable laws, regulations, and ordinances of the United States and the State of South Carolina. If any such violation, misuse or non-compliance occurs, the Lessor, upon giving the Lessee a reasonable time in which to effect good compliance and sixty (60) days written notice of its intention to terminate this lease, shall have the right to re-enter and take possession of the premises, and lease the Site to a third party, at the option of the Lessor.

In the event of changes in the laws or regulations applicable to the Site for disposal of radioactive waste which makes such continued operations by Lessee impossible or economically unfeasible, Lessee shall have the right to terminate this lease upon reasonable notice of not less than six (6) months to Lessor.

In the event of termination, nothing contained herein shall give rise to any claim by Lessee against Lessor under this lease, and the Lessor and Lessee may mutually agree upon Lessee's use of the Site for another reasonable purpose; provided, however, the Lessor and Lessee shall then enter into such agreements or amended agreements as will insure the continuation of the perpetual care fund established April 21, 1971, and continued pursuant to Paragraph 7 of this lease.

In no event shall Lessor be prevented from using the Site for storage and disposal of radioactive wastes and materials generated within the State of South Carolina or from entering into any agreement with a third party to dispose of such wastes and materials on any basis whatsoever.

In the event of condemnation of the Site by exercise of the power of eminent domain, this lease shall terminate as of the date title is taken. Such termination shall be without prejudice to the rights of either party to recover compensation from the condemning authority for loss or damage caused by such condemnation, and the fair market value of the Site shall be determined as the value of the highest and best use for such property, including, but not limited to, the use of the Site for disposal of radioactive waste. Unless the State of South Carolina institutes legal proceedings to condemn Lessee's leasehold interest, Lessee shall not seek to claim loss or damage from Lessor for the loss of such interest. No action by the State of South Carolina or any agency thereof, except condemnation by exercise of the power of eminent domain, shall be deemed a taking by the State of South Carolina.

Lessee specifically agrees to indemnify and hold harmless Lessor, its successors and assigns, of any from any and all damage, loss or liability for personal injury or property damage which may result or arise out of Lessee's operation of the Site, including, but not limited to, the payment of all reasonable fees and expenses incurred in the defense of any such claim made against Lessor by way of lawsuit or otherwise.

Lessee further agrees to cooperate fully with Lessor should any other claim be made against Lessor for any reason whatsoever; provided, however, that such cooperation shall not give rise to any pecuniary loss or expense to Lessee except as may arise as a result of a claim or suit against Lessee.

Neither this lease, nor any term thereof, shall operate to restrain the Lessor, when acting in its capacity as Sovereign of the State of South Carolina, from fulfilling its responsibilities as Sovereign, including, but not limited to, a determination on the part of the Sovereign that a public emergency exists and that immediate State action is necessary.

Nothing contained in this lease shall be construed as a waiver by the State of South Carolina, acting through the Budget and Control Board, of its Sovereign Immunity.

Except as hereinabove amended, the lease agreement dated April 6, 1976, shall remain in full force and effect.

IN WITNESS WHEREOF, the parties have hereunto set their hands and seals, in duplicate, this _______ day of _____________, 1979.

Signed, sealed and delivered in the presence of:

____

____

Irving L. Butler

J. L. McDaniel

STATE BUDGET AND CONTROL BOARD
OF SOUTH CAROLINA
LESSOR

BY___________________________(LS)

CHEM-NUCLEAR SYSTEMS, INC.
LESSEE

BY___________________________(LS)

STATE OF SOUTH CAROLINA)
)
COUNTY OF RICHLAND)

PERSONALLY appeared before me ______________________________ and made oath that _he saw the within named State of South Carolina, acting through the State Budget and Control Board, by Richard W. Riley, Governor of South Carolina, sign, seal, and as the act and deed of the State, deliver the within written Amendment to Lease; and that _he with ____________________________ witnessed the execution thereof.

____

Sworn to before me, this _________
day of ___________________, 1979.

____________________________(SEAL)
Notary Public for South Carolina
My Commission Expires __________

STATE OF WASHINGTON)
)
COUNTY OF KING)

PERSONALLY appeared before me J. L. McDaneld and made oath that _he saw the within named Chem-Nuclear Systems, Inc., by Bruce W. Johnson, its President, sign, seal, and as the act and deed of the said Corporation, deliver the written Amendment to Lease; and, that _he with Irving L. Becker witnessed the execution thereof.

J. L. McDaneld

Sworn to before me, this 11th
day of September, 1979.

Barbara Fischer (SEAL)
Notary Public for Washington
My Commission Expires October 15, 1980

STATE OF SOUTH CAROLINA)
) ss. LEASE AGREEMENT
COUNTY OF BARNWELL)

This lease agreement made and entered into, in duplicate, this 6th day of April 1976, by and between the State of South Carolina, acting through the State Budget and Control Board, hereinafter called the Lessor, and Chem-Nuclear Systems, Inc., hereinafter called the Lessee, a corporation duly organized and existing under the laws of the State of Washington, and, heretofore, on August 4, 1969, was authorized to do business in the State of South Carolina, having its registered office in Barnwell, South Carolina, and authorized to engage in the business of storing and disposing of radioactive wastes and materials by Radioactive Material License Number 097 issued by the South Carolina Department of Health and Environmental Control.

WHEREAS, Lessor, by and through the State Budget and Control Board, has determined that a facility for the storage and disposition of radioactive wastes should be opened in the State of South Carolina to assist in the development of the peaceful benefits of nuclear energy in the State; and

WHEREAS, Lessee has procured and caused to be conveyed to the Lessor the real estate hereinafter described, which real estate is hereinafter referred to as the "Site;"

NOW, THEREFORE, in consideration of the payments reserved herein and the mutual covenants made by the parties, it is agreed as follows:

WITNESSETH

1. That the said Lessor for and in consideration of the rents, covenants and agreements of the Lessee, as hereinafter set forth, does hereby rent, lease, and demise unto the said Lessee the following described premises:

A TRUE AND CORRECT COPY
Anne D. Franklin
CLERK OF COURT, BARNWELL CO. S.C.
6-10-76

All that certain piece, parcel or tract of land, with improvements thereon, situate, lying and being in Barnwell County, State of South Carolina, as shown on plat prepared by J. J. Foy, R.L.S., dated January 7, 1976, and, according to said plat, having the following metes and bounds, to-wit: Beginning at a point located on the North side of South Carolina Road S-6-53 at SRO Monument No. 129 and running thence North 38 degrees 15 minutes East for a distance of 669.5 feet to a point; thence North 38 degrees 15 minutes East for a distance of 20.5 feet to SRO Monument No. 128; thence North 10 degrees 10 minutes West for a distance of 4132.43 feet to SRO Monument No. 123; thence North 65 degrees 43 minutes East for a distance of 1303.73 feet to an iron pipe; thence North 66 degrees 18 minutes East for a distance of 1508.67 feet to an iron pipe; thence North 58 degrees 22 minutes East for a distance of 82.42 feet; thence South 05 degrees 35 minutes East for a distance of 99.87 feet to an iron pipe; thence South 38 degrees 08 minutes West for a distance of 2516.94 feet to an iron pipe; thence South 02 degrees 24 minutes West for a distance of 344.45 feet to an iron pipe; thence South 88 degrees 06 minutes East for a distance of 1811.86 feet to a pipe; thence South 04 degrees 09 minutes East for a distance of 2443.68 feet; thence North 86 degrees 23 minutes West for a distance of 168.6 feet to an iron pipe; thence South 27 degrees 29 minutes West for a distance of 1063.01 feet; thence North 84 degrees 49 minutes West for a distance of 308.67 feet; thence North 07 degrees 22 minutes East for a distance of 159.94 feet; thence North 76 degrees 05 minutes West for a distance of 223.58 feet to an iron pipe; thence North 84 degrees 08 minutes West for a distance of 614.75 feet to a point; thence North 64 degrees 06 minutes West for a distance of 570.31 feet; thence south 39 degrees 39 minutes West for a distance of 283.45 feet; thence South 27 degrees 22 minutes West for a distance of 363.95 feet to a point; thence North 70 degrees 46 minutes West for a distance of 98.66 feet to a point thence North 68 degrees 47 minutes West for a distance of 41.62 feet to the point of beginning, being SRO Monument No. 129.

Together with all the rights, privileges and appurtenances thereunto belonging.

2. To Have and to Hold the said premises hereby demised unto the said Lessee, its successors and assigns, for a period of ninety-nine years, commencing on the 6th day of April, 1976, and to terminate on the 5th day of April 2075, unless sooner terminated in accordance with the terms of this lease, at a yearly rental of $50.00 per year, the first annual payment being due and payable upon execution of this lease, receipt of which is hereby acknowledged, and succeeding payments to be payable annually within ten days after the anniversary date of this lease. The rental

payments shall be payable in lawful money of the United States at the principal office of the State Budget and Control Board, or as otherwise designated in writing by the Lessor.

3. The Lessee agrees that this lease shall not be assigned without the Lessor's written consent, which consent will not be unreasonably withheld. This lease may be assigned to a wholly owned subsidiary of the Lessee organized under the laws of the State of South Carolina. The State of South Carolina, specifically the Budget and Control Board and the Department of Health and Environmental Control, must be notified prior to any assignment.

4. The Lessee agrees that it will not without the written consent of the Lessor, which consent will not be unreasonably withheld, sublet the premises or any part thereof or permit the use of the premises by any party other than the Lessee or a wholly owned subsidiary of the Lessee organized under the laws of the State of South Carolina. The State of South Carolina, specifically the Budget and Control Board and the Department of Health and Environmental Control, must be notified prior to any sublease.

5. The Lessee covenants and agrees that it will use the leased premises in all respects in accordance with the laws of the United States Government, the laws of the State of South Carolina, and also in accordance with the requirements specified in South Carolina Radioactive Material License Number 097 and all amendments thereto. It is expressly understood that the Lessee shall comply with all requirements of the United States Nuclear Regulatory Commission, and the State of South Carolina, and applicable laws and rules as the same are promulgated and amended from time to time.

6. The Lessor or any person authorized by it shall at all times have access to the leased premises for all reasonable purposes including, without limitation, the protection of the health and safety of the public or of the employees, personnel, or contractors of the Lessee, for taking readings

and samples to facilitate research and taking readings or samples to gain information needed for the Lessor's promotion of nuclear industrial development, and for inspecting the premises and determining if the Lessee is complying with the obligations imposed by this lease.

7. The Lessee understands that the storage and burial of radioactive wastes requires perpetual surveillance and maintenance, and so long as it occupies the site, the Lessee will undertake all surveillance and maintenance as required by all applicable laws, regulations, and licensing requirements for the protection of the public health and safety. The Lessee further understands that if for any reason at any time the Lessee should default or fail to comply with the terms of its license or for any reason withdraw from the premises, the Lessor would be required to assume surveillance and maintenance obligations and pay the surveillance and maintenance costs. The Lessee, therefore, covenants and agrees to pay to the Lessor, at quarterly intervals, the sum of 16 cents for each cubic foot of radioactive waste buried at the Site during the preceding quarter. Said sum shall be increased every three years on the anniversary date of this lease in accordance with the following formula:

> In accordance with the Consumer Price Index for all items for the "South" region as published by the Department of Labor in the Current Labor Statistics - Monthly Labor Review utilizing the March, 1976 index as the base.

The parties expressly agree hereby that upon expiration or earlier termination of this lease, all materials buried at the Site prior to such expiration or termination shall remain so buried and shall be thereupon owned by and the sole and exclusive reponsibility of Lessor, its successors or assigns. The parties also recognize that the escrow fund set up by the parties pursuant to agreement dated April 21, 1971, for perpetual care of the waste buried at the Site shall continue to be maintained and the payments made pursuant to this paragraph shall be added to such fund. Interest earned upon said fund shall accrue to the fund. In order for the Lessor to determine the proper payments of the Lessee, the Lessor shall have access to and the right to examine any pertinent books, documents, papers, accounts and records of the Lessee involving operations on the leased premises. Lessee further covenants to surrender all receipt and burial records to Lessor five (5) years after the ending of the fiscal or calendar year to which the records pertain or within one (1) year after vacating the Site. Surrendered records will be made available at the request of the Lessee.

8. The Lessee will not, without the Lessor's consent, violate any of the terms and conditions of this Lease, will not violate the terms of authorizing licenses issued by the South Carolina Department of Health and Environmental Control and the Nuclear Regulatory Commission or any other appropriate authority, will not use any part of the lease premises in a manner not in compliance with the covenants and purposes of this lease, or will not fail to comply with any applicable laws, regulations, and ordinances of the United States and the State of South Carolina. If such violations, misuse, or non-compliance occurs, the Lessor shall have the right, upon giving the Lessee a reasonable time in which to effect good compliance and sixty days written notice of its intention to terminate this lease, re-enter and take possession of the premises, and lease the Site to a third party, at the option of the Lessor. However, in the event of changes in the laws or regulations applicable to the Site for disposal of radioactive waste which makes such continued operation by Lessee impossible or economically unfeasible, ceasing to use the Site for its present purpose and using the Site for another reasonable purpose shall not be considered a violation, misuse or noncompliance with this Lease; provided, however, in the event that changes in the applicable laws and/or regulations make continued operation economically impossible or unfeasible, prior to the use of the Site for any other reasonable purpose by the Lessee, the Lessor and the Lessee herein, shall enter into such agreements or amended agreements to be negotiated and agreed upon between the Lessor and the Lessee, as will insure the continuation of the escrow account

and perpetual care fund established April 21, 1971, and continued pursuant to paragraph 7 of this lease agreement.

Neither this Lease, nor any terms thereof, shall operate to restrain the Lessor, when acting in its capacity as Sovereign of the State of South Carolina, from fulfilling its responsibilities as Sovereign, including but not limited to a determination on the part of the Sovereign that a public emergency exists and that immediate State action is necessary.

In the event of condemnation of the Site, the fair market value of the Site shall be determined as the value of the highest and best use for such property, including, but not limited to, the use of the Site for disposal of radioactive waste and the Lessee shall be entitled to the portion of any condemnation award allocable to the use of the Site during the remaining term of this lease.

9. The Lessee agrees that the Lessor's failure to insist upon the strict performance of any provision of this lease, failure to exercise any right based upon a breach thereof, or the acceptance by the Lessor of any rent during such breach shall not waive any of the Lessor's rights under this lease.

In the event of any dispute between the parties with respect to any of the terms or provisions of this lease or alleged violations thereof, such disputes shall be submitted to arbitration by a disinterested person to be known as the Arbitrator, who shall be appointed as follows:

> Either party may give written notice to the other of a dispute, briefly describing it and requesting arbitration thereof. Each shall, within ten (10) days after receiving such notice, appoint in writing one disinterested party and these disinterested parties as appointed, shall, within ten (10) days of their appointment, choose the Arbitrator, who shall determine the matters in dispute forthwith; the award or determination as made by the Arbitrator

shall be final and binding upon the parties hereto respectively and their respective successors or assigns.

10. The matter of whether any alleged violation of this Lease is substantial enough to warrant its termination under the provisions of paragraph 8 hereof shall be a proper subject for decision by the Arbitrator as described above. In the event that the Arbitrator concludes termination of this Lease would be warranted under the facts of the matter, Lessee shall have a reasonable time after the Arbitrator's decision to effect good faith compliance prior to sending of the sixty days written notice of intent to terminate this lease. The Arbitrator shall specify the items at issue on which good faith compliance is necessary to avoid termination and a reasonable time for such compliance.

11. Any notices, demands, requests, consents, approvals, and/or other communications which may be or are required to be given by either party to the other under this Lease shall be in writing and shall be deemed to have been sufficiently given for all purposes when delivered or mailed by certified mail, postage prepaid. Notices to the Lessor shall be given by mailing to the Budget and Control Board, 205 Wade Hampton Office Building, Columbia, South Carolina 29201 and to the Department of Health and Environmental Control, 2600 Bull Street, Columbia, South Carolina 29201. Notices to the Lessee shall be given by mailing to Chem-Nuclear Systems, Inc., Post Office Box 1866, Bellevue, Washington 98009.

12. Execution of this Lease by Lessor and Lessee shall terminate and replace any presently existing Lease between the parties related to the premises described herein and shall terminate and replace that certain agreement between the parties dated April 21, 1971, under which an escrow fund for perpetual care of waste buried at the Site was established.

13. That the Lessee shall provide all hazard and fire insurance at its own proper expense on all outbuildings, fixtures and other personal

property situate on the leased premises, with loss payable provisions in favor of the Lessee. The proceeds from any hazard or fire insurance shall be used by the Lessee to replace all or so much of said outbuildings, fixtures or other personal property as may be economically reasonable and feasible.

IN WITNESS WHEREOF, the parties hereto have executed these presen in duplicate, the day and year first above written.

Signed, sealed and delivered
in the presence of:

[illegible]

[illegible]

[illegible]

[illegible]

STATE BUDGET AND CONTROL BOARD
OF SOUTH CAROLINA,
LESSOR

By James B. Edwards

CHEM-NUCLEAR SYSTEMS, INC.,
LESSEE

By [illegible]

STATE OF SOUTH CAROLINA)
)
COUNTY OF)

PERSONALLY appeared before me [illegible] who, in oath, says that __he saw the within-named State Budget and Control Board of South Carolina by Gov. James B. Edwards its Chairman sign the within Lease Agreement, and the said Corporation by said officer, seal said Lease Agreement, and, as its act and deed, deliver the same, and that __he with [illegible] witnessed the execution thereof.

[illegible]

Sworn to before me this 6th

day of April, 1976.

[illegible] (SEAL)
Notary Public for South Carolina

My Commission Expires: April 1979

STATE OF WASHINGTON)
)
COUNTY OF KING)

PERSONALLY appeared before me ~~DAVID F. JONES~~ who, in oath, says that __he saw the within-named Chem-Nuclear Systems, Inc., by BRUCE W. JOHNSON its President sign the within Lease Agreement, and the said Corporation, by said Officer, seal said Agreement, and, as its act and deed, deliver the same, and that __he with J. L. McDANELD witnessed the execution thereof.

Sworn to before me this 24th day of May, 1976.

Phyllis J. Lozier (SEAL)
Notary Public for The state of Washington

My Commission Expires: Nov. 24, 1979

STATE OF SOUTH CAROLINA

COUNTY OF BARNWELL

Chem-Nuclear
&
State of S.C.

LEASE AGREEMENT

April 6, 1976

Amendment
September 11, 1979

BROWN, JEFFERIES & BOULWARE
ATTORNEYS & COUNSELORS AT LAW
BANKERS TRUST BUILDING
BARNWELL, SOUTH CAROLINA 29812

NRC FORM 335 (7-77)

U.S. NUCLEAR REGULATORY COMMISSION

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2. *(Leave blank)*

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7. AUTHOR(S)

5. DATE REPORT COMPLETED

MONTH November YEAR 1981

DATE REPORT ISSUED

MONTH January YEAR 1982

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

Same as above

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT

Environmental Assessment

PERIOD COVERED *(Inclusive dates)*

15. SUPPLEMENTARY NOTES

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

This Environmental Assessment was prepared by the U.S. Nuclear Regulatory Commission in response to a request by the South Carolina Department of Health and Environmental Control, Bureau of Radiological Health, for technical assistance in evaluating the impacts of the Barnwell facility. Alternatives in the following areas were considered in the assessment: (1) No Action; (2) Operational Procedures; (3) Financial Guarantees for Compliance, and; (4) Methods of Minimizing the Potential for Radionuclide Release and Transport over the Long Term. Environmental impacts were evaluated for the following actions: (1) Closing the site and implementing site closure and stabilization plans; (2) Continuing operations under current conditions, and; (3) Continuing operations under altered conditions.

17. KEY WORDS AND DOCUMENT ANALYSIS

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17b. IDENTIFIERS/OPEN-ENDED TERMS

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